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Topics of the Month

Why go to the U.S. to study pollution control?

THE Chemical Products Committee of the Organisation for European Economic Co-operation has proposed that experts from member countries should visit the United States in the autumn to study methods used there to combat air and water pollution caused by the chemical industry. The committee feels that a study of the solutions found by the Americans would greatly help the European chemical industry. With due respect we doubt this. Our doubt is grounded in the opinions of the British Chemical Productivity Team which, while finding much to praise in its tour of America, unanimously concluded that British effluent disposal practice was greatly superior to American. The team quoted a British government survey which stated that most American rivers were the most heavily polluted on earth. This is because American legislation, or the lack of it, permits effluents to be discharged either to rivers or to the sea, into the air or into the ground, without much chemical treatment and, therefore, with low labour and capital cost. According to the team's report, 'In the south, greater use was made of private lakes, or of nearby rivers or seas ... for the disposal of liquid effluents, but in the west the vast stretches of desert received the lot.'

There does not seem much here that would help solve European problems. When it comes to gaseous effluents there is even less. Again to quote the team's report: 'In America there were no federal laws to cover the treatment

of noxious gases from chemical works, although a few of the individual states had, or were now introducing, legislation, and there were no federal chemical factory inspectors. We found it easy to locate some of the chemical factories from afar by the brown cloud of oxides of nitrogen discharged from their chimneys. Usually this discharge of noxious gases was permitting plant to be operated above design capacity, so that the profit from increased production more than offset the cost of a lower materials efficiency. Where raw materials were cheap this might have been good for productivity, but it was certainly beginning to arouse the interest of local smoke-abatement committees. In Great Britain it would be the subject of legal action by Her Majesty's Alkali Inspectors.'

Where American industrial centres have cleaner air than elsewhere it is due to the use of oil, natural gas and electricity, not to superior effluent disposal.

This picture of a land so vast and accommodating that industry can more or less discharge at will its noxious wastes compares strikingly with the rigid control enforced in Britain where, for instance, in one factory alone £250,000 have been spent on effluent disposal equipment employing from 15 to 20 men for its operation. We think that the committee would spend less money and get better value if it sent its experts to see the best in British effluent disposal and pollution prevention and, moreover, it would gain knowledge suitable for the more crowded conditions of Europe.

Porous plastic

NEW uses are being sought for a microporous form of polyvinyl chloride originally invented by a British firm as a replacement for wood for storage battery separators. The negative and positive plates of a battery must be separated from each other and supported by a material which is mechanically strong and simultaneously porous enough to allow the free diffusion of electrolyte. Cedar with its resins removed was the traditional material, but it broke down comparatively quickly under the chemical action occurring in the battery, leading to premature failure. Indeed, for years the wood separator was recognised as the weakest component of a battery. This was changed during the war by scientists at the Dagenham factory of Pritchett & Gold & E.P.S. Ltd., battery makers. They discovered a way of making a uniformly porous sheet of PVC which had all the merits of wood as regards diffusion of electrolyte plus indefinite resistance to corrosion. It had two other advantages: it could be made thinner than wood, thus allowing closer positioning of the battery plates with consequent higher performance; and it could be formed into envelopes to protect the edges and corners of the plates.

A few weeks ago we saw the manufacture of this material, *Porvic*, at Dagenham. Six parts of maize starch are mixed with one part of PVC and a non-toxic solvent—e.g. isophorone or dimethyl cyclohexanone—in a Werner Pfeiderer type mixer for about 2 hr. The 'dough' is then extruded into ribbed strips which are passed through a tunnel oven to drive off the solvent, recovery of which is of the order of 80%. The strips, now consisting of maize starch and PVC, are then treated with hot dilute acid to hydrolyse the starch, which is then easily dissolved out with water. This leaves a porous plastic with air cells about 15 microns in diameter connected to each other by openings of the order of 1 micron. After further treatment the plastic is treated with a wetting agent to make it accept water and it is then ready for cutting to the sizes required for battery separators. At Dagenham, weekly production in a new plant is now about 250,000 sq. ft. of standard material 0.03 in. thick. Half as much again is made in another factory in Lancashire. This output is sufficient to meet present battery manufacture requirements and leave a margin for other uses.

The manufacturing process, which is covered in British Patent 565,022, is claimed to permit the manufacture of PVC with uniform pore size. This pore size can be controlled by using more or less starch. Finely powdered starch is used because it has remarkably regular granules. The uniform and regular porosity of *Porvic*, combined with its chemical inertness, is thought to make it of great potential use as a filtration medium. Obviously it will have limitations owing to the fact that PVC is attacked by some solvents and is thermoplastic, softening at around 80°C. Nevertheless, these microporous diaphragms would appear to have many filtration uses.

Calcium monosilicate for building

FORMED by the process of steam-hardening from cement and siliceous sand together with aluminium powder, water and other chemicals and substances, *Siporex*, which is a calcium monosilicate compound, has, over the last few years, been rapidly gaining popularity as a building material in Sweden and other parts of the world.

Based on a discovery in 1933 by Swedish civil engineer

Ivar Eklund and cement scientist Prof. Lennart Forsén, then in the employ of the leading Swedish cement group, Skånska Cement AB., of Malmö, the process of manufacturing this building material consists of mixing the various components in correct quantities for the required use of the finished product, casting in moulds, air-hardening and steam-hardening. The latter is done in an autoclave, the pressure of the steam being gradually increased. *Siporex* has good bearing capacity, is almost unshrinkable, can be worked like wood yet is as weatherproof as stone, is non-inflammable, fire-resistant and has good insulating properties.

It is at present made in five factories in various parts of Sweden whose present capacity is about 400,000 cu. m. (14,124,000 cu. ft.) p.a. Such is the lag between supply and demand, however, that extensions permitting of a further production of approximately 100,000 cu. m. p.a. are planned.

Siporex is also manufactured in Norway, Denmark, Finland, at Riga and Reval (now Russian), France and Germany. Other plants are being built or are planned for Poland and other European countries, Latin America, U.S.A., Australia and Africa.

Petroleum chemicals; a new industry in France

THE first chemical plant in France to produce acetone and its by-products from propylene supplied by the Shell-Berre oil refinery has started operations in Berre, near Marseilles. This plant was built at a cost of 1,800 million francs by the Shell-St. Gobain firm in the record time of 16 months, using the experience gained by the Shell company in Britain, Holland and the United States. The Shell-St. Gobain firm was jointly set up by Shell Française, French subsidiary of Royal Dutch-Shell, which holds 60% of its capital, and the French chemical firm, Manufactures des Glaces et Produits Chimiques de St. Gobain, Chauny et Cirey, which owns the remaining capital.

The new plant has already started production of isopropyl alcohol and acetone and will be able to produce methyl-isobutyl-ketone, diacetone alcohol and methyl-isobutyl-carbinol in a few months. While isopropyl alcohol is used as raw material for the production of acetone, excess quantities may be sold as solvents.

The plant's annual capacity of 7,500 tons of acetone and mixed solvents, added to that of other plants nearing completion, will bring France's total production capacity to 20,000 tons of acetone p.a. This will make the country independent of imports and save the equivalent of \$700,000 p.a. Moreover, the chemicals produced in this plant will be about 30% cheaper than those made from acetone by the fermentation process.

Consumption of acetone and methyl-isobutyl-ketone is expected to increase, since domestic prices will not be at international levels, so that French manufacturers will be able to cope with international competition.

Other plans to set up petro-chemical plants in France are under way. A subsidiary of the electro-chemical company Sté. d'Electrochimie, d'Electro-Metallurgie, et des Acieries électriques d'Ugine, is already producing the same chemicals as Shell-St. Gobain, but has to import the isopropanol which it processes to obtain these products. It plans to produce butanol and methyl-ethyl-ketone from butylene.

The Raffineries de Pétrole de l'Atlantique, in co-operation with several chemical firms, is erecting a plant in Donges (western France). This plant is to produce cumene, phenol and acetone.

Naphtachimie, founded by Pechiney, Société Générale des Huiles de Pétrole (in which the Anglo-Iranian Oil Co. has an interest) and the chemical firm, Ets. Kuhlmann, is to produce ethylene oxide, glycols, glycol ethers and ethanolamines from ethylene and isopropanol and isopropyl acetate from propylene.

Another chemical firm, Rhône-Poulenc, will produce phenol and acetone from benzene and propylene in Roussillon, southern France.

Extrusion briquetting of wood waste

TWO methods of briquetting wood waste have been developed since the war, one in America and the other in Europe. Briquetting waste from saw-mills or other forms of wood-working obviates the necessity for burning it on the premises, or paying for its removal. The compressed material is more easily and cheaply handled than bulk sawdust and can be sold profitably.

The American method of briquetting is by means of the *Pres-to-log* machine. In this, semi-fibrous sawdust is fed to a large stainless-steel auger screw, by which it is compressed and driven through high-ratio worm reduction gear through a 4-in.-diameter nozzle. The compressive end load on the screw is over 80 tons and it is driven by a 75-h.p. motor. The material is compressed at a specific pressure of 8 to 10 tons p.s.i. The machine uses the friction heat generated to raise the temperature of the wood waste to 350°F., well above the flow temperature of wood gums and lignins. These plasticise, permitting a partial fibre flow and a log of very high density results.

For after-cooling, a large indexing wheel in which are arranged 60 water-cooled cylindrical bores is used. The extrusion screw drives the log into the first bore. The wheel then indexes hydraulically, shearing off one hot log and presenting the second bore to the orifice nozzle. This happens 60 times, until the first log is again opposite the nozzle and is ejected by the new incoming hot log.

The material must be pre-dried, the highest permissible moisture content being about 4%. After final extrusion, the logs are cut into 1-ft. lengths and packed in units of six. They burn slowly with intense heat, and do not throw sparks.

Wood briquetting in Europe has been pioneered by Pawert AG, of Switzerland, whose *Glomera* machine differs radically from the American model. Successive charges of wood waste fall in front of a piston and are driven by a motor, linked by a crank and knuckle, through a conical extrusion nozzle. A high rate of compression is obtained with a minimum friction and heat rise. After extrusion, the logs pass to a water-cooled split tunnel, known as the after-pressure head, which provides the necessary counter-friction and can be adjusted to suit the varying requirements of the material, such as particle size and moisture content. These machines are generally three-nozzle units and the working parts lie under a hermetically-sealed hood. A small centrifugal fan within the hood provides some air pressure to keep out dust and also some air cooling.

The briquettes are of about the same density as *Pres-to-logs* (1.1 to 1.2) and are hard, slow-burning and efficient. They have been found when tested to be more economical in use than coal.

Glomera briquettes are also sold mechanically wrapped in paper or *Cellophane*, with the open ends varnished, under the trade names *Papakt* and *Cellopakt*.

Raw materials from waste dumps

TUNGSTEN dust from grinding sludge, boiler fuel from waste oil and lagging material from asbestos dust are some of the treasures which firms have discovered in their waste dumps after experiments by the Coventry Industrial Salvage Group.

The Group is not officially supported; it is a private venture by a number of companies. Until 1950, it came under the auspices of the Midland Region Industrial Salvage Advisory Council. When, for economy reasons, the Board of Trade withdrew support from the Council, the Coventry Group decided to carry on.

The three examples mentioned, which are typical of their work, are reported in the Government publication, *Target*. The tungsten dust was recovered by a firm of machine toolmakers from grinding sludge, by using a rotary magnetic separator. Sixty per cent. extraction is obtained, the content of tungsten being as high as 17%.

A way has been found for the same firm to burn waste oil in furnaces with an atomiser, saving 1,200 tons of coal p.a.

A brake-lining firm threw away asbestos dust residue until advised by the Group that, mixed in equal parts with warm water and silicate of soda, it produced a useful lagging paste, as efficient and less expensive than normal lagging material.

Another example of the Group's work was the discovery of a market for 2 tons of short ends of rayon silk every week, previously thrown away. The firm concerned now sells them at 6d. lb.—making £100 a week.

An aircraft company now collects 2 tons of aluminium from floor sweepings every month. The same firm salvages 1,000 broken aircraft skinning clamps, costing 3s. each, each week and returns them to the makers for repair.

Two firms in the Group find it worth while to recover lead and zinc dross from smelting. The Group found a market and the dross is sold instead of being dumped.

By aiding its 70 member-firms like this, the Group is saving thousands of pounds and conserving raw materials by substituting salvage. All its members have pledged themselves to use salvage as much as possible and freely lend their laboratories and technical facilities.

Many Group members already run special salvage departments in their factories.

The secretary of the Coventry Industrial Salvage Group is Mr. H. J. Bryant, Salvage and Recovery Department, Armstrong Whitworth Aircraft Co., Baginton, Coventry. Firms in any part of the country may ask for information on salvage problems.

Corrosion preventives for engineering parts

DURING the war most manufacturers of engineering equipment and spares were required to protect them against corrosion during transportation, in many instances overseas, as well as during storage, and the British Standards Institution published Section 3 of B.S. 1133, 'Packaging Code,' to provide assistance at that time. Some firms have continued to apply the temporary corrosion preventives to ordinary commercial goods, but many abandoned this procedure after the war, not recognising that the need still remained to ensure that equipment remains in a good state from the time of manufacture to usage.

There is still, however, a considerable failure to safeguard engineering equipment exported. Perhaps because many items, particularly mass-produced parts, are used relatively

quickly when not exported, there has been a more persistent failure on the part of some manufacturers to realise the considerable deterioration that can occur during transit and during storage in this country. Goods in wagons or on lorries are often not protected against rain or they are put into contact with damp wood; this is mainly a packaging problem, but corrosion prevention is also necessary. In storage it is often impossible to provide good conditions; industrial atmospheres are usually corrosive, unheated stores are common, large articles and equipments often have to be stored outside, spare parts may have to be kept for several years before they are wanted, and so on. Corrosion preventives that can easily be removed when an article is fitted (the so-called 'temporary corrosion preventives') are widely used in some works and are freely available from a considerable number of manufacturers. What is required is a wider recognition of the need for them, the setting up of standards of performance, and guidance on their suitability for particular exposure conditions and types of articles, on the supplementary wrapping and packaging that individual materials require, and on relative costs. The British Standards Institution has recently issued Section 6 of the Packaging Code B.S. 1133 to provide this information.

This Section 6 of B.S. 1133 is an adaptation of the wartime Section 3 to ordinary commercial practice. Whereas the former edition referred extensively to Government department specifications, performance specifications for the temporary corrosion preventives have been formulated in the present edition. The general scope remains broadly the same as before: not only are temporary corrosion preventives and their uses described in detail, but the essential preliminary conditions are catered for by an extensive section on cleaning (covering all the well-established methods of dealing with oil, grease and dirt and including the removal of rust and scale) and a short section on drying.

The document, which costs 10s. 6d. from the B.S.I., London, has been carefully prepared in order that it shall serve the dual purposes of a directly readable handbook on the subject and a reference book. It will meet the needs of technical people, but has been prepared also with the ordinary packer as a reader in mind.

Flooded refinery again on stream

A HEARTENING example of how prompt action and loyal and devoted effort helped to reduce the material losses inflicted by the calamitous East Coast floods is provided by the story of the Coryton (Essex) refinery of the Vacuum Oil Co. Ltd. This installation went on stream on Saturday, January 31, the climax of 2½ years of construction work. Within a few hours great gusts of wind were whipping across the flat marshland, the Thames rose steadily and during the night the refinery site was flooded. With only 15 minutes' grace, the night shift stopped production of gasoline and thus reduced the terrifying risk of fire. Out on the tank field the manholes of empty tanks were opened so that the waters filled them and prevented them from floating away. Throughout Sunday, labour and materials were assembled and by Monday morning 4,000 men were filling the breached dykes with sandbags; 200,000 were placed in position in 48 hours. When it was possible to examine the damage closely it was soon found that no buildings, foundations or units were seriously harmed. Electrical equipment and construction supplies suffered most. Repair work started immediately and within 21 days the refinery was once more

back on stream. To commemorate this achievement the company have issued a booklet which tells the story in words and pictures and pays tribute to all who laboured so well to bring it about.

Industrial furnace improvements

EARLY in 1949 an international organisation, the Flame Radiation Research Joint Committee, was set up with the object of studying flame radiation and its effects upon the efficient operation of furnaces and boilers. Three countries—Britain, France and Holland—were the founder members and today there are three more—America, Belgium and Sweden. There is a national committee in each country which seats two representatives on the Joint Committee. The work is financed by industries interested in flame radiation, for example, chemicals, oil, cement and glass, and by the manufacturers of water tube boilers. The organisation has a research centre at IJmuiden, Holland, where work is concentrated on improving the efficiency of industrial furnaces. Recently the chairman of the British Committee, Prof. O. A. Saunders, introduced a discussion before the Institute of Fuel on the research being done at IJmuiden. He said that results obtained to date had led to a better understanding of heat transfer processes—in particular of heat transfer by flame radiation. Heat transfer by radiation from luminous flames was mainly due to suspended carbon particles. We lacked knowledge of the number and size of these particles, and their rate of formation. The problem was a complex one, and could not be studied satisfactorily in the laboratory; investigations were needed on a scale approaching that of the furnaces actually used in industry. Such investigations had been carried out at IJmuiden over the past four years.

Mr. M. W. Thring (general superintendent of research to the committee) said that the earlier experiments were of two types—'performance trials' and 'combustion-mechanism trials.' In the performance trials the effect on the flame radiation of the following pairs of variables was compared: (a) oil and creosote pitch; (b) rate of fuel energy input, 76 and 106 therms/hr.; (c) air and steam as atomising agents; (d) an increase of 20% in the quantity of atomising agent; and (e) an increase of 25% in the quality of combustion air. In the combustion-mechanism trials the object was to measure in great detail the conditions inside the flame, with a view to finding an explanation of the results of the performance trials. For example, the structure and distribution of the soot particles in flames had been studied by means of the electron microscope.

In the second series of experiments (the 'burner trials') the effect on the flame characteristics of using various types of burner was studied. At first the experiments were confined to oil fuel, but later comparison was made between coke-oven gas and oil as fuel. It was shown that (1) in the early part of the flame the radiation from coke-oven gas is much lower than for oil, (2) in both cases the most important effect on flame radiation is that of jet momentum and (3) the emissivity of the flame depends on the square of the soot concentration, if the soot is formed by two molecules meeting.

The next stage in the work would be to apply the new knowledge concerning the effect of jet momentum on flame length, and the relative effects of air and steam as atomising agent, to improving burner design. And studies would be made of the radiation from pulverised-fuel flames in water-tube boilers.

PETROLEUM CHEMICALS

Achievements and Aims of the Industry in the United States

By Martin Buck

(Shell Chemical Corporation)

The author reviews some of the major developments in the American petroleum chemicals industry to illustrate what is being done to make the most of the sound basic raw material position that this industry possesses through the use of all phases of technology. Tremendous advances have been made to fill the demands of the chemical industry for more new products at minimum prices, to continue supplying the older products as cheaply as possible and thereby stimulate the development of new uses for them, and to fill gaps of supply by supplementing limited existing sources.*

MUCH has been written and said about the startling growth of chemicals from petroleum hydrocarbon raw materials. The recent unprecedented growth is a matter of record, and the literature seems to be flooded with forecasts of demand and methods of forecasting demand. Rather than add to these many statistics, perhaps it is timely to examine some of the fundamental factors which determine the growth of any chemical, and note why these factors are so strongly influencing petrochemical growth.

The demand for any product is determined by both utility and price. The organic chemical literature teaches us how to make hundreds of thousands of compounds, but relatively few have reached substantial volumes in the market place. Most either cost too much or have insufficient utility. It is not enough to produce an interesting molecule of little utility, even for a low price, nor is it sufficient to produce a useful molecule priced too high. Substantial sales volume can only be achieved when both utility and price demands are met.

Fundamentally, therefore, chemicals from petroleum hydrocarbons have been produced in large volumes only when they were useful and could be sold at the right prices. As an obvious corollary, as utility increased and/or price could be reduced, sales volume, or growth rate, generally increased.

Now let us apply this elementary economics to what is happening in the petrochemical field. In the first place, it was natural for the petrochemical industry to gain its entry into the chemical economy largely by supplying existing raw materials, intermediates, and occasionally consumer products, at lower prices. It is to be emphasised that utility of these materials was already established and growth rate could be and was stimulated by lower prices. Lower prices were made possible by a plentiful and reliable source of raw materials, a continually improving technology and the cumulative effect of still larger volume. Raw materials in this classification include the organic chemical building blocks, ethylene, propylene, butyl-

enes and, more recently, cyclopentadiene, benzene, toluene, xylenes and acetylene; intermediates include the primary and secondary alcohols from the olefines mentioned, acetone and higher ketones and, more recently, glycerin and phenol. The natural or coal tar sources of these materials were augmented and in some cases largely displaced. The list is far from complete—it is growing, and it will continue to grow as long as the utility remains and the price is right.

We now come to the next stage in petrochemical growth. Having established a plentiful supply of low-cost raw materials and intermediates, great stimulus was given to the development of new products where the estimated price was right but the utility had to be established. This took a little longer, but soon began to account for the rapid growth of recent history. Usually there was competition with existing products, but occasionally birth was given to an entirely new field. At this stage, also, competition between processes as well as competition between products became important factors tending to keep costs low.

Processes and products

Let us dwell a moment on this important point of competition between processes and between products. It is characteristic of the industry and its highly developed technology to establish competitive processes for manufacturing the same commodity. Examples are many. A few include three methods for manufacturing ethyl alcohol—two from ethylene and one by the Fischer-Tropsch process; two methods for manufacturing isopropyl alcohol—one by direct catalytic hydration and one utilising sulphuric acid; two methods for making *n*-butyl alcohol—one by the oxo process from propylene and one by condensation of ethyl alcohol; three methods for manufacturing acrylonitrile—one starting with acetylene, one with ethylene and one with propylene; two methods for manufacturing ethylene

oxide—one by direct oxidation and one by the chlorohydrination route; three methods for manufacturing vinyl chloride one from acetylene and two from ethylene; at least three methods for manufacturing phenol—the latest being the cumene hydroperoxide route which adds to the older processes utilising chlorine or sulphuric acid; two methods for manufacturing phthalic anhydride—one from *ortho*-xylene and one from naphthalene; and at least two methods for manufacturing acetylene from hydrocarbons—the Wulff process and the Sachsse process, to add to the older route from calcium carbide. Commercial success breeds competition not only in process but also in product, and the industry abounds with examples. In the solvent field isopropyl alcohol competes with ethyl alcohol and acetates compete with ketones; the polyhydric, glycerin, pentaerythritol, propylene glycol and diethylene glycol compete with each other; polyvinyl chloride competes with polythene, vinyl chloride copolymers compete with polystyrene; epoxy resins compete with the phenolics; diallyl phthalate resins compete with melamine. These are some of the fruits of research of a dynamic industry. The list could be extended to include many more, but the important point is the energetic use being made of all phases of technology to supply needed petrochemicals at the lowest possible price.

New products

Now let us return to the developments of new products where the estimated price was right but the utility had to be established. Time will permit mentioning only a few of the more important segments of the petrochemical field. Perhaps the most rapidly growing segment is the organic chemicals used in the agricultural field. I am referring to the synthetic organic insecticides, herbicides, defoliant and soil fumigants which have developed only in the last ten years to an estimated sales volume of \$125 million in 1951 at the manufacturers' level and before formulation. In this case the rate of development of technology coincided with the supply of raw materials and intermediates for the

*Paper presented at the Semi-Annual Meeting of the Manufacturing Chemists' Association Inc., New York, November 25, 1952.

low-cost manufacture of the chemicals. They include DDT, methoxychlor, benzene hexachloride, *Chlordane*, *Aldrin*, pentachlorophenol, aromatic oils, DD, ethylene dibromide and many others. They have been a major factor in maintaining the nation's agricultural production at the needed high level. Increasing the world's production of food and clothing from its limited amount of arable land is so basic that it is hard to conceive greater direct utility for an organic chemical. Technological activity in this field is great, and we can confidently expect continued rapid rate of growth, fundamentally, again, because the utility is there and the price is right. Before leaving the agricultural chemical field let us mention nitrogen fertiliser. At least two companies now in petrochemicals in this country started in the field *via* the manufacture of nitrogen fertilisers utilising hydrocarbons as the source of hydrogen for ammonia. Again, few things are more fundamental than nitrogen for the soil to grow more food and clothing. When nitrogen fertiliser could be produced synthetically at the right price, its continued growth was assured.

The most important segment of the petrochemical field dollar-wise is the polymer segment which utilises high molecular weight compounds for the manufacture of rubber products, synthetic fibres, moulded plastics, laminates, adhesives, prints and plastic sheeting and film. The current dollar value of this field before processing has been estimated at \$2 billion p.a., excluding the natural and cellulosic polymers. Here again we have seen tremendous growth because the raw materials and the intermediates were available at the right price and the utility of the finished products developed rapidly.

The most important segments of this field are synthetic rubber, synthetic resins including fibres, and plastics. Synthetic rubber was developed under crisis conditions during World War 2, and American technology earned one of its greatest tributes by doing the job so well that both the price and the quality now successfully compete with the natural product. This is undoubtedly the most important example of a steady trend, the use of synthetic organics to augment and then partially replace a time-honoured natural product. The value of the synthetic rubber produced annually today is more than \$250 million, and continued growth can be expected at a faster rate than the general economy.

We are all aware of the recent rapid growth rate of synthetic resins, including the resin fibres, which have now reached an annual value approaching \$1 billion. Improved synthetic resins for the protective coating field are rapidly changing the character of this industry. The basic reason is, once more, better products at the right prices. The plastic field follows the same pattern. Merely to mention a few of the petrochemicals industry's con-

tribution to the high polymer field is sufficient to illustrate its dependence upon low-cost raw materials and intermediates for its continued growth. Even a partial list sounds like a chemical dictionary and includes butadiene, styrene, isobutylene and isoprene for rubber; acrylonitrile, *paraxylene*, ethylene glycol, vinyl chloride, vinyl acetate, cyclohexane, acetic anhydride and ethyl chloride for fibres; vinyl chloride, styrene, phenol, formaldehyde, acrylonitrile and acetone for plastics; dibasic acids, polyhydric, styrene, epichlorohydrin and phenol for resins. The high polymer field truly is carving an important place in our economy to provide us with clothing and shelter. It will continue to grow as long as the prices are low enough.

In the field of synthetic detergents we

have another example of great stimulus to development from the availability of a plentiful supply of raw materials at low cost. In this case, utility superior to the available natural product was the goal, and its success is measured by the magnitude of the national annual business which exceeded \$15 million in 1951. The price was right, the utility was more than competitive, and we see the birth and growth of a new industry based largely on alkyl aryl sulphonates in the U.S. and alkyl sulphates in other countries.

There is nothing startling about the growth of chemicals from petroleum hydrocarbon raw materials. It has been merely the supply of the basic needs of mankind—food, clothing and shelter, with sufficient utility at the right price.

Potash Refining in France

THE potash basin in Alsace, which covers about 85 sq. miles, has reserves of 300 to 323 million metric tons of K_2O , enough, it is estimated, to supply world requirements for a century at the present rate of consumption. In 1947, the Potash Mines of Alsace started a ten-year plan with the aim of raising potash production from 600,000 tons p.a. of K_2O to 1.2 million tons by 1957. According to L. Garès, in a paper given recently before the Fertiliser Society in London, output is already approaching the million tons p.a. mark.

Describing the manufacturing process, Garès states that seven factories are engaged in the refining of the crude potash salts. The aim is to obtain high-grade potash salts 50 to 60% K_2O (75 to 95% KCl) from the crude potash-bearing ore (sylvinites) and to eliminate the impurities such as common salt (sodium chloride), slime, shales, anhydrites ($CaSO_4$), etc., that accompany the ore. The average composition of the French sylvinites is: 25 to 35% KCl; 55 to 65% NaCl; 10% insolubles.

First the ore is ground in the grinding mill adjoining the hoisting shaft. The ore is dumped into a hopper, then on to a pan feeder and delivered to hammer mills or crushers which reduce the size of the big lumps and then on to crushing rollers where they are broken down to small pieces of about 5-in. size. The ore goes on afterwards to another series of crushing rollers where it is finely ground and screened to minus 5 mm. Taken as it is, this ground raw material is a marketing product called 'sylvinites', i.e. 'manure salt' containing 18 to 22% pure potash, minimum guaranteed 18% K_2O . The absence of hygroscopic magnesium salts in the French potash deposits allows these raw salts to be ground and used direct as straight fertilisers. The major part of this ground sylvinites (about 95%), however, goes to the factories.

After having passed through the grinding

mill, the ground sylvinites is conveyed by belt conveyor to the factory for treatment. There it is stocked in a hopper ready to be fed to the dissolvers.

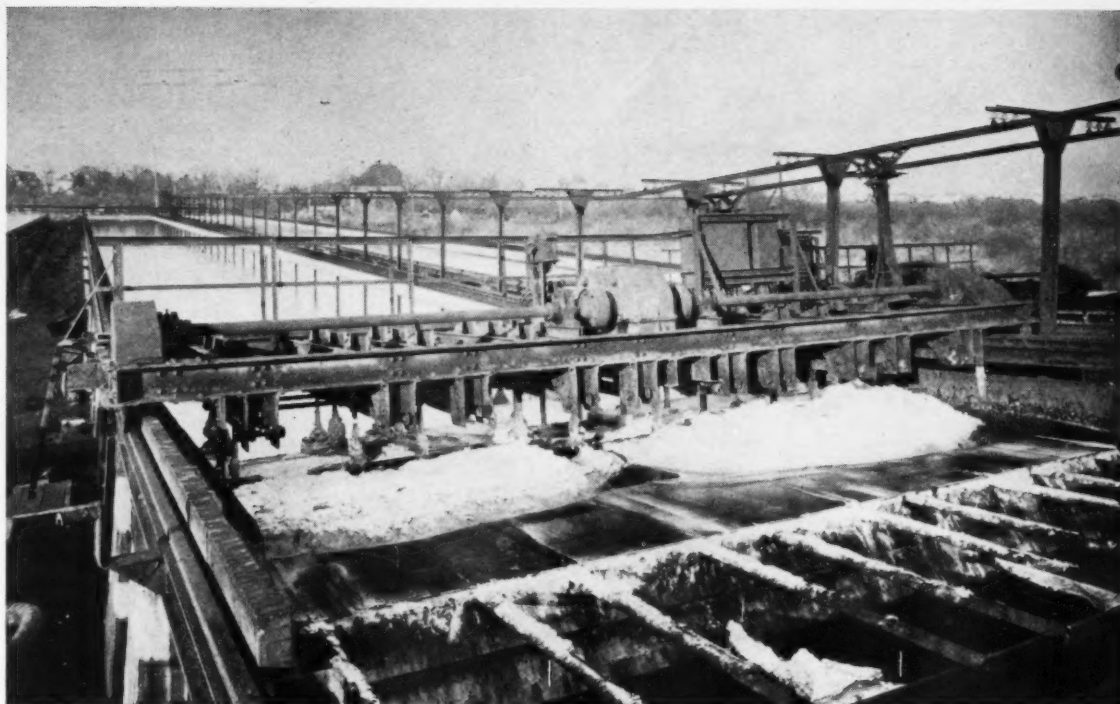
The potassic mineral is a crystalline mixture of sylvite (KCl) and halite (NaCl) and the refining consists essentially in removing the sodium chloride from the potassium chloride. The refining process is based upon a simple solubility relationship between sodium and potassium chlorides. In general, no double salts are formed in the temperature range employed; the separation depends upon the relative depression of solubility in water which the two chlorides exert on each other.

The solubility of sodium chloride alone in water increases by only a small amount with increments of temperature and the direction of its saturation curve is actually reversed in solutions saturated with potassium chloride.

The aim is to obtain in theory a hot solution of about 212 to 230°F., saturated with both sodium and potassium chlorides. On cooling this hot solution saturated in respect to both salts, the potassium chloride precipitates copiously while the sodium chloride remains substantially in solution. The mother liquor coming from this operation, on being heated to its original temperature, is no longer saturated with potassium chloride (owing to its precipitation), but is still saturated with sodium chloride. Applied to sylvinites, this hot mother liquor dissolves the potassium chloride and leaves the sodium chloride undissolved. On cooling, the potassium chloride drops out of the solution. This operation is carried out in vacuum coolers.

Refining

The refining process involves a cycle of heating and cooling. We start with a cold mother liquor coming from a previous operation saturated with sodium chloride, but unsaturated as regards potassium



Out-door crystallising vats at the Alsatian potash mines.

[Courtesy: Fertiliser Society]

chloride. The mother liquor, on the basis of 100 gr. of water at temperature of 68°F., contains 14.7 gr. of KCl and 29.2 gr. of NaCl. The liquor is brought to a temperature of about 230°F., first by passing through the heat exchangers where it takes up 70% of the heat coming from the vacuum coolers, and secondly by being pumped to the pre-heaters where it is brought to the point, *i.e.* 230°F., by means of a steam coil using directly the steam coming from the power station.

The dissolving operation is carried out in a continuous dissolver, *i.e.* a long vat or trough provided with a spiral conveyor and certain number of heaters fixed inside which are meant to keep up an equal temperature all along the vessel. The ground raw salts coming from the hopper are charged from the top at one end and the hot mother liquor is introduced at the other. The dissolution takes place counter-currently. The potassium chloride is dissolved, but the sodium chloride remains undissolved. The latter drops to the bottom of the vat and is conveyed out by the spiral conveyor. A bucket elevator takes it up to a rotating table, where it is washed so as to recover the KCl that it may still retain, then drained and afterwards discarded.

The enriched mother liquor, unencumbered with slime, shales and other impurities, goes on to a Dorr thickener and clarifier for clarification. Here, while this slime settles down, the overflow which constitutes the clear part is sent to the vacuum coolers. The thickened underflow, which is made up of insolubles and clayey slime, is pumped to a battery of

Dorr thickeners and washed. The mother liquor and the potassium chloride are recovered and recycled back to the dissolvers; as for the slime and insolubles, they are taken away by a bucket conveyor and sent on to the tailings.

After decanting, the hot enriched mother liquor coming from the Dorr thickener and clarifier goes on to the vacuum coolers to be cooled.

The complete cycle of potassium chloride crystallisation is carried out in two stages. In the first, the hot saturated solution, which is pumped to a four- or five-stage vacuum cooler, is submitted to evaporation under vacuum. This brings a fall in the temperature of the liquid, thereby a cooling and a partial crystallisation of the potassium chloride.

The solution enters the first-effect vacuum cooler at about 204°F. and leaves the last one at 107°F. This means a total temperature drop of 97°F., which induces the crystallisation of the potassium chloride.

The steam resulting from the evaporation is piped to the condensers so as to warm up the mother liquor used in the dissolving process.

Prior to 1926 the cooling operation was carried out in open-air vats. Vacuum cooling was then introduced on a large scale. This process turned out to be very satisfactory. It is rapid; it makes it possible to recover the heat of crystallisation (60 to 70%) and prevents the caking of cooling surfaces; it has the advantage of yielding a free-flowing slurry of crystals in suspension which can easily be drained; it reduces the period of

cooling from days to a few minutes and also yields products of high purity.

The crystallised potassium magma coming out of the vacuum coolers is sent afterwards to the draining vessels (settling tanks), where it is separated from the mother liquor by draining off the latter. The mother liquor from this operation goes directly to a reservoir from whence it returns to the factory where, heated again, it will serve to treat further amounts of ground sylvinit.

The overflow from the draining vessels, which is still tepid, is sent to the open-air vats where a second crystallisation of potassium chloride takes place. The potassium chloride crystallises out and is separated from the mother liquor by the same draining process.

The potassium chloride after draining is delivered to a rotary cylindrical furnace for drying. It is then conveyed to the warehouse for storage or to the bagging machines, or on to the goods trucks.

The muriate of potash is reclaimed from storage by means of an electric scraper. This machine discharges the muriate to a belt conveyor, thence on to an elevator to the loading station. It is delivered either to the bagging machines or to the bulk truck loaders. Samples are taken out at regular intervals and are analysed to control the quality of the product.

The muriate is bagged on automatic machines and the bags sewed on power sewing-machines. They are loaded on to the trucks by conveyor. Truck loaders are used for bulk potash.

(Concluded on page 102)

BURSTING DISCS

INSTITUTION OF CHEMICAL ENGINEERS' SYMPOSIUM

Since the early 1930s, bursting or rupture discs have become recognised as valuable pressure safety devices for chemical plant. Indeed, they have several advantages over relief valves, although in many cases it is still legally necessary to fit valves. Recently, in London, the Institution of Chemical Engineers held a symposium on bursting discs at which six papers were presented. Materials of construction, design, fitting and applications of discs were comprehensively discussed. Below we present brief summaries of these papers.

Design and application

BURSTING disc design and application in the chemical industry was discussed by Mr. D. J. BREEZE, of Monsanto Chemicals Ltd. His firm had been using them since about 1935. Bursting discs were used because relief valves were not completely foolproof and had a certain amount of inertia. A properly designed bursting disc could be guaranteed to burst at a pressure not exceeding a stated maximum. It had little inertia and, on failure, provided an unobstructed opening. It could be used for protecting equipment subject to explosions and could be installed so that it was difficult for anyone to tamper with it. It was stressed, however, that bursting discs were seldom used where relief valves could provide adequate protection and that, in many cases, provision of a relief valve was statutory.

The types of disc and their mountings were then discussed. Discs, whether flat or dished, were best secured between special flanges. Care was required in designing the mounting. All bursting discs had a limited life, sometimes only a few days, and should be easily and quickly replaceable. Frequently, vented fluids had to be taken some distance from the vessel. If the disc was a small one, the pipe flanges could be sprung apart to permit disc replacements or a section of piping might be removable. For larger discs, it was customary to provide some means of raising the vent piping, or to provide a short stack above the disc which telescoped into the piping. Mounting the disc in an inspection box was another solution. A cowl fitting on the vent or, where explosion risk existed, tarred paper secured by wire, gave protection from rain seepage.

Disc materials were then discussed. Special reference was made to Monel metal, with a guaranteed bursting pressure, which was available in America, and to discs of copper, silver, rubber-covered lead and glass, available from British firms but not guaranteed.

The specification, testing and installation of bursting discs were the responsibility of the engineering department. Data furnished in 1939 by Lake and Inglis was used as a rough guide in assessing the material and thickness, the minimum size of the disc having previously been calculated to give adequate venting area. Trial discs were cut and tested. Purchased

discs were tested in the same way, as were all materials for discs. All discs, whether cut or obtained from stores, were installed by the engineering department and care was taken to ensure that application was always correct.

The design of vessels not subject to explosion risks was discussed with particular reference to British Standard Code 1500: 1949, it being noted that the vessel must be built to withstand the maximum bursting pressure of the disc at any stage of the operations, which may be higher than its designed pressure under normal operating conditions. The same code also states that the total capacity of the safety device and its associated piping must be sufficient to discharge the maximum quantity of fluid without permitting a rise of more than 10% above the permissible working pressure in the vessel. When possible, the disc should be mounted close to the vessel.

The design problem for vessels subject to internal explosion risks was much more complicated. Generally speaking, the designer of such a vessel could not expect much assistance from the literature. The rupture disc bursting pressure was fixed by normal operating conditions. The vent ratio must be somewhere between 2 and 10 sq.ft./100 cu.ft. and the number of discs carefully assessed so that none was too far from a possible seat of initiation. There was need for more data.

Twelve typical disc applications in the chemical industry were then described. In conclusion, the speaker observed that he had never had any experience of a disc not operating when it should. It was not always easy, however, to ensure that it would operate within a narrow range of pressures. Good design and good inspection and maintenance were necessary to minimise risk of premature failures.

Bursting and isolating discs in chemical plant

The design and use of bursting disc assemblies in the chemical industry was discussed by Mr. F. MOLYNEUX, who also described the application of isolating discs to the control of certain chemical processes.

He pointed out that the shear or isolating disc had only recently been designed for a specific purpose in the industry. The bursting disc had certain advantages over the safety valve, notably in the protection

of reaction vessels from the danger of a rapid and excessive rise of pressure. The bursting and isolating disc gave a full opening for the passage of materials, had little inertia and could be made cheaply from any metal with adequate resistance to heat and corrosion.

Pure metals were preferable to alloys, because they were homogeneous and discs made from them would thin uniformly and burst at a definite pressure. The following metals had been used very successfully: platinum, gold, silver, copper and aluminium, nickel, lead and tin, Monel metal, stainless steel and brass and cast iron. Rubber was not very successful, but synthetic rubber had given more satisfaction. Types of discs included: the flat plate, which was the most frequently used; the die-scored disc, for cases where it was required to eject a complete pellet; the spheroidal or commercial type of disc; the bowler hat or wide-groove spheroidal disc, which had been found most useful for accurate work; shear discs operated by a punch; and the magnetic bursting disc. This was based on rupturing, not the disc itself, but magnetic lines of force.

Uses of bursting discs in the chemical industry ranged from comparatively small diameter discs on reaction vessels and stills of tar and coke oven plants and throughout the petroleum industry to the very large discs or explosion vents used on plant engaged in the production of explosive chemical compounds.

Isolating and shear discs were extensively used in the design of chemical propellant plant. Special types of discs and housings developed for such work were described. In this case, the housings and discs were used as isolators. Two or more liquid chemicals had to be expelled into the combustion chamber. Once started, the reaction proceeded very rapidly and it was essential that the correct sequence should be adhered to very accurately. The use of bursting discs in the feed lines was found to be the only solution to these problems, since it ensured that before flow began, pressure had attained a definite value at which it remained throughout the reaction. The disc, once ruptured, did not restrict the flow. A special cage retained the burst pellet and prevented its motion, causing a fluctuation. Pressure was applied from

an inert gas bottle *via* a shear disc, operated by an electrically ignited detonator applying pressure to a shear plunger. The reactions could thus be initiated in whatever sequence was required.

These pipeline isolating discs were operated at low pressure and used, in most cases, on small-bore lines. They were usually of lead with small traces of copper to reduce creep. They had to be thinned down on the bursting edge to a few thousandths of an inch and, as considerable difficulty was encountered through the creep of this metal, they were finally used either with a lip or a reinforcing bead. All were prepared by pressing in a special punch and were die-set under controlled conditions. Fabricated discs were pre-tested, and samples tested were found to break within $\pm 5\%$ of the pressure expected. Isolating discs were used in these ways at a range of bursting pressures of from 25 to 300 p.s.i. with aniline, hydrazine, nitric acid, calcium and sodium permanganate solutions, hydrogen peroxide, methanol, ethanol, aviation spirit, liquid oxygen and liquid anhydrous hydrofluoric acid.

Tubular bursting elements

The development of a tubular type of bursting element, suitable for use at very high pressures, was described by MR. W. R. D. MANNING, of Imperial Chemical Industries Ltd. Pointing out that the conventional bursting disc becomes increasingly difficult to operate at pressures much above 500 atmospheres, mainly because of a tendency to creep, he described some tubular bursting elements evolved by his firm and successfully used at 1,000 atm. by their Plastics Division.

The development was based on two assumptions, which appear to have been justified by results. The first is that the strains in the axial direction are negligible compared with those in the transverse directions, and the second that the relationship between maximum shear stress and maximum shear strain is the same in the cylinder wall as it is in a torsion specimen. All experience obtained was, of course, based on room temperatures. A bursting pressure curve for different diameter ratios having been obtained by means of these two assumptions, the proportions of the required tube could be read off from the resulting curve. The next consideration was the approximate capacity and energy of the system to be relieved by the bursting element; in this case it had to prevent the pressure from rising beyond an agreed limit and so protect the rest of the plant from damage. Another important consideration from the point of view of safety was that the bursting element should be surrounded by an adequate outer tube and vent to lead the ejected fluid well away from the working space.

In the plant described, tubes were made with $\frac{1}{2}$ -in. bore and an outside diameter of 0.64 in. Thickened ends were well radiused

into a parallel length of at least twice the outside diameter. The plant was carrying hydrocarbon gases at a working pressure of about 1,000 atm. and the desired bursting pressure was 1,050 atm. For even greater accuracy it was found helpful to make two elements in tandem from the same bar. These were tested and, when one burst, the other was judged to be on the point of doing so. This latter was cut off and used.

In the short working life of the plant—250 hr.—the device worked satisfactorily and was easily renewed. It was considered to have the advantages of being able to form part of the high-pressure pipe system, where it would be unlikely to block but where a block would be discovered at once, of being simple to prepare and fit and of being able to be relied upon to burst within $2\frac{1}{2}\%$ of the chosen pressure.

Design and manufacture of disc assemblies

The design of disc holders and the choice of disc materials were discussed by DR. J. M. PIRIE and MR. J. F. W. BROWN, of Johnson, Matthey & Co. Ltd. They also dealt with the manufacture and testing of discs and the general use of assemblies.

They considered that the greatest disadvantage of bursting discs was the difficulty of ensuring that discs fitted successively in the same holder would always break under the same pressure. A lesser difficulty was to ensure that a disc would still break, some time after fitting, at the same pressure as when first fitted. While the properties of the disc itself were fundamental, careful design of the holder was also essential for satisfactory function.

Almost always, the holder was arranged so that the disc would be spherical just before bursting. In order to obtain repeatable behaviour it was necessary to hold the foil so that stresses were uniformly distributed and as nearly as possible purely tensile. An adequate radius on the downstream lip of the holder would meet the second requirement. The first was more difficult to meet. For holders with orifices of over 1 in., flat-faced flanges with faces machined smooth and truly perpendicular to the main axis were satisfactory, though a number of more elaborate designs had been evolved to obtain uniform clamping pressure. Bolted-flange holders could also be designed with a number of special features. These included capsule holders to be assembled in the workshop and inserted as a unit.

Where choice of discs was concerned, the only two conditions to be specified were material and thickness. Almost all discs were metal and it was desirable to use pure, fully annealed metals. High ductility was very desirable. Nearly all requirements of disc material could be met by silver, nickel, aluminium or platinum; copper, palladium or gold might sometimes be needed. Regarding thickness, it had been well established that the

pressure at which foil of a given thickness would burst when correctly mounted was inversely proportional to the orifice diameter. The effect of changing thickness of foil had not been so clearly established. Lake and Inglis' theory appeared to be affected by the smoothness of surface of rolled foil. In practice, of course, selection of correct thickness was determined experimentally and checked by test. It was important to adhere closely to a specification for metal for a disc, agreed between manufacturer and user. The points to be covered in preparing this were summarised.

Foil for the manufacture of bursting discs should be homogeneous and repeatable. The finished product should be uniform in thickness to within a few ten-thousandths of an inch. Great care was needed in manufacture and handling.

The authors referred briefly to the effect of elevated temperature on bursting pressure of discs, that of creep and to the provisions of B.S. Code 1500:1949, mentioned in an earlier paper. They also mentioned the valuable tendency of bursting discs to 'fail to safety,' that is to break at a lower pressure than that specified, never at a higher, if there were any inherent defects in manufacture or assembly.

Testing ductile metals

A method of examining ductile foils for use in bursting discs and means for their application in practice were described by MR. T. B. PHILIP, of the Distillers Co. Ltd.

After reviewing the literature on the subject, he went on to describe work undertaken by his own firm, including the standard test evolved. Specifications based on normal tensile tests being relatively useless for assessing the suitability of metals for disc foils, final tests must be made on the foils themselves. The requirements of the standard test are that it should give consistent results, should be simple and provide as much information as possible in the shortest time.

In the apparatus devised by the Distillers' Co., a disc is fitted under a 1-in. diameter orifice in a holder, which, on the low-pressure side, is connected to a liquid gauge. The approximate bursting pressure of the disc is either known or can be determined by a preliminary test. The test procedure is then as follows: the pressure is increased steadily on the underside of the disc by a screw ramp pump and in 30 sec. is raised to approximately 80% of the bursting pressure. In another 30 sec., it is raised to bursting pressure, the burst being clearly indicated in the liquid gauge. Gauge and pressure readings are taken and, after the test, the extensions as indicated by the gauge are plotted against corresponding pressures. A number of metals have been tested and it has been found that if the period of test is extended to, say, 5 min., the metals are liable to creep with possible reduction in bursting

pressure. Results on a number of metals show that, for all practical purposes, the bursting pressure is proportional to the thickness. The bursting pressure of a combined disc—one containing metal with good chemical resistance but bad creep resistance combined with another having the opposite qualities—can only be predicted by consideration of the respective extensions of each of the components.

The results of examination of creep properties of a number of metals were found to tally with information already published.

Over 100 tests were carried out with pulsating pressures, and in no case was there any evidence that work-hardening or other effect on the disc caused a bursting pressure above the standard one.

It was confirmed that discs assume the form of hollow spherical segments up to pressures closely approaching the bursting pressures. Immediately before bursting, a relatively minor bulge usually formed at the point of rupture.

Discussing the specification of foils, the speaker said that it was important to maintain a stock of these of known characteristics, so that replacements could be supplied from original stocks. He referred to the examination of synthetic plastic materials by the standard test procedure. Results indicated that foils of polythene or PTFE would fulfil the need for discs on low-pressure systems. Plated metal had been tested, but its use was not recommended.

Regarding the design of disc holders, it was essential that the orifice should not present a sharp edge at the periphery of the disc. Another important point was that the fitting of discs of incorrect strength into holders should be prevented. This could be done by designing the holder so that part of the disc was visible externally, or by arranging holder, orifice and disc so that the whole system was mechanically interlocked and it was physically impossible to fit any but the correct orifice and disc.

Reference was made to discs with vacuum supports for cases where the disc was subjected to vacuum or pressure. A method of manufacture of formed bursting discs and bursting discs with vacuum supports, based on hydraulic prestressing of a master disc into which further discs and vacuum supports, if required, were hydraulically extended, was outlined.

The practice of fitting two bursting discs in series in cases where bursting pressure was little above working pressure was discussed. When a disc failed inconveniently early, either or both could be replaced without loss of the contents of the system. The use of discs in parallel with interlocking shut-off valves between them and a conventional relief valve following each disc was also referred to.

In conclusion, the advantages of pre-formed discs were mentioned. These were firstly psychological, the user realising that he was handling something special.

Secondly, in the case of hydraulically pre-formed discs, it was often possible to detect abnormalities such as pin holes or surface damage.

Assembly for special conditions

A description of a bursting-disc assembly for alternating pressure and vacuum at elevated temperatures was given by Mr. E. A. K. PATRICK, of the North Thames Gas Board. A very compact totally enclosed steam heating system consisted of a small flash boiler in which steam was generated. The steam was then condensed in the platen of a press used for the moulding of thermosetting resins. A certificate of general exemption from certain provisions of the Factories Act was obtained, which waived the requirements that a pressure gauge, safety valve, water-level indicator and fusible plug or low-water alarm should be fitted, provided that they were replaced by a thermometer and bursting disc to burst at 300 p.s.i. The disc was to be so placed or shielded as to prevent its injuring anyone on bursting. In addition to these requirements, the disc had to withstand a normal operating pressure of 200 p.s.i. and a vacuum generated by condensation of the steam when the platen was not in use. It had to be steam- and air-tight under pressure and vacuum, easily renewable but not easily tampered with, and accommodated within a vertical height of 2 in. at the side of the platen.

It was decided to mount the disc in a plug screwed into the edge of the platen, so that the entire assembly could be

replaced in the field, while the recharging of plugs with new discs would be done on the bench to eliminate unsupervised handling of the fragile and valuable disc material, platinum. Three designs of holder were evolved, the third proving satisfactory and eliminating earlier difficulties. It is the subject of British Patent Specification No. 648,100. In it a body is provided with a $\frac{1}{2}$ -in. parallel B.S.P. thread for screwing into the body of the vessel to be protected. The end face is provided with an annular rib of rounded section which seats on a polished face in the body of the vessel. The other end, also polished, serves as the seat for the bursting disc, which is held down by a hollow cone. This, in turn, is held in position by a clamping cap which screws on to a $\frac{3}{8}$ -in. B.S.P. thread. The whole assembly is of steel. Holes of $\frac{5}{16}$ in. diameter are drilled in the cone and clamping cap.

For the disc itself, silver was first tested, but the elevated temperature was above the annealing temperature of the silver. This produced creep, resulting in a failure of the disc to burst at the specified temperature. The material which seemed most likely to be satisfactory was platinum. This was not found to be prohibitively expensive, a $\frac{1}{2}$ -in. diameter disc of suitable thickness costing about 5s. Tests were, therefore, made with platinum, first in a special apparatus and then under works conditions. Foil 0.0033-in. thick, designed to burst at 300 p.s.i., was used with satisfactory results.

New process for nitric oxide production

Nitric oxide is produced directly by heating air above 2,000°C. and chilling the product quickly to prevent dissociation by a new process, the Wisconsin, which is claimed to supersede the two previous processes, the Birkland-Eyde and the Haber.

In the Wisconsin process, as described by M. Narasinga Rao (*Journal of Scientific and Industrial Research*, India, 1952, 11 (11), 512-513), nitric oxide is produced by the direct oxidation of air in a gas-heated furnace constructed of magnesia refractory. It has been found possible to heat air to temperatures above 2,100°C. by regenerative heating in a pebble-bed furnace constructed of magnesium oxide pebbles. Water-gas or producer-gas of low heating value (150 to 200 B.Th.U./cu.ft.) may be used in the process, in which the principle of regenerative heating and cooling is employed economically and efficiently. Nitric oxide concentrations of 1.5 to 2.5% have been obtained in commercial furnaces. The nitric oxide is oxidised to NO_2 and absorbed. This second stage of oxidation, carried out in a homogeneous reactor, is slow because of the low concentration of NO_2 in the reaction mixture and its non-catalytic nature. Larger chamber space is required for the homogeneous reactor for satisfactory conversion.

Kinetic data for the oxidation of nitric acid, using silical gel as catalyst, have been obtained by American workers who established the apparent mechanism of the reaction and evolved a method for the process design. Activated carbon is reported to be a more efficient catalyst.

The Wisconsin process has been developed on a pilot-plant scale at San Jose, California, by the Food Machinery Co., and has been working satisfactorily for over three years. A commercial plant costing \$2 million is in the process of erection at the Sunflower Ordnance Works, De Soto, Kansas.

Potash Refining

(Concluded from page 99)

It needs 3 to 4 tons of sylvinitite to make 1 ton of muriate, according to the potash content of the ore. The factories deliver the greater part of their production in salts containing 40 to 50% K_2O and also 60 and 62% K_2O , a special grade for the manufacture of compound fertilisers and chemical products.

The types of potassic fertilisers delivered by the French Potash Mines of Alsace are: muriate of potash (60% K_2O and 50% K_2SO_4); potash manure (40% K_2O); sylvinitite (18% K_2O); sulphate of potash (48% K_2O).

PUMPING PRACTICE

Pumping solids; centrifugal pumps; seals, packings and joints; reciprocating pumps; handling volatile liquids; new and improved pumps

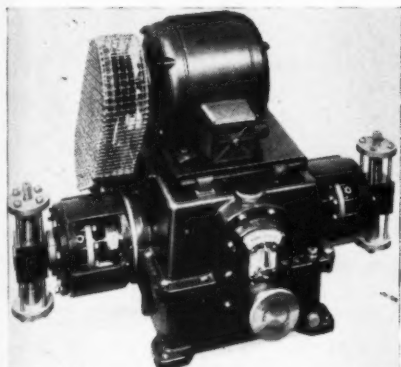
By A. Flindle, M.I.Mech.E.

Hydraulic conveyance of solids

THE most interesting development in pumping practice since the last review (November 1951) is the proposal by the Ministry of Fuel to pump coal through a 100-mile-long pipeline from the Midlands to London. This project was discussed in the March issue of this journal, where it was also pointed out that the National Coal Board has a pilot coal-pumping unit working.¹ Fundamental work on this profoundly interesting subject of hydraulic conveyance of solids is being done by the British Hydromechanics Research Association. It is very briefly discussed in the Association's fifth annual report.

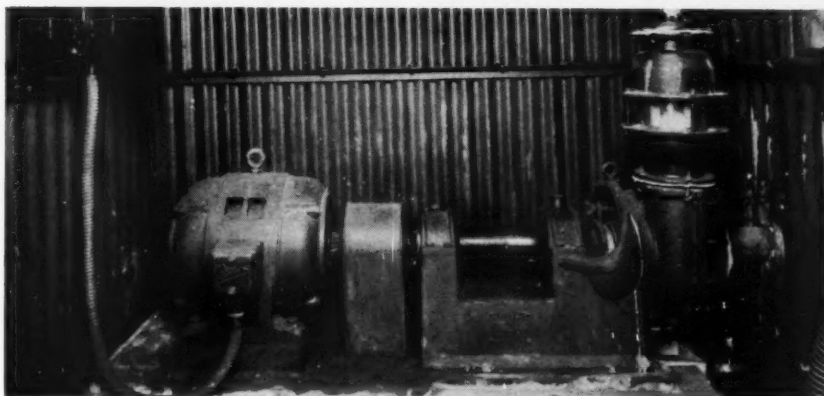
Centrifugal pumps

Another piece of research being done at



[Photo: The Candy Filter Co. Ltd.]

Metering pump designed to incorporate high-pressure fluid seals. It is capable of delivering up to 11 gal./hr. against a pressure of up to 3,000 p.s.i. The fluid seal is maintained at a pressure in excess of the pump delivery pressure so as to ensure that there is no leakage of the liquid being pumped, an essential feature when especially noxious liquids are handled. The gearbox is a standard Candy 'Vari-stroke' type which permits the output of the pump to be varied simply by rotating the handwheel on the outside of the box. Variation can be made while the pump is in operation. The pump head is in 18/8 stainless steel. The ram is fully supported in the gearbox and there is no contact between the ram and other metal parts in the pump head, thus avoiding the necessity of using differing materials. Duplicate suction and delivery valves are used. In this particular unit, the Candy 'G' Minor, the packing material is polytetrafluoroethylene in square section and disc form.



[Photo: L. A. Mitchell Ltd.]

Centrifugal acid pump, one of a range specifically designed to combat corrosion. The makers claim that the pumps will handle all acids at any concentration (except hydrofluoric) without the necessity of using special metals and alloys. They are of the volute type centrifugal design with all contact parts in chemical stoneware which, in addition to its corrosion resistance, is resistant to abrasion, enabling the pump to be used for pumping acid slurries and suspensions when fitted with open-type impellers instead of the closed type normally supplied for standard acid pumping duties. The hydraulic design of the pump ensures a slight vacuum on the gland when in operation, which is said to eliminate gland leakage. Provision is made for either water or grease lubrication of the glands. The exterior of the pump is heavily armoured with close-grained cast iron to give a unit of robust mechanical design. The impeller shaft is carried in widely-spaced bearings in a separate pedestal to prevent any journal load on the gland. The front bearing is of the oil-ring-lubricated sleeve type, providing a rigid support to the impeller head, while a combined thrust-and-journal ball bearing is provided at the outer end of the shaft. The pumps are suitable for either direct or vee belt drive; in the latter case the pedestal is designed to carry the pulley between the bearings to ensure more even load distribution than is the case with an overhung pulley. The complete range of pumps covers capacities up to 500 gal./min. and for certain sizes of pumps heads up to 100 ft. can be accommodated.

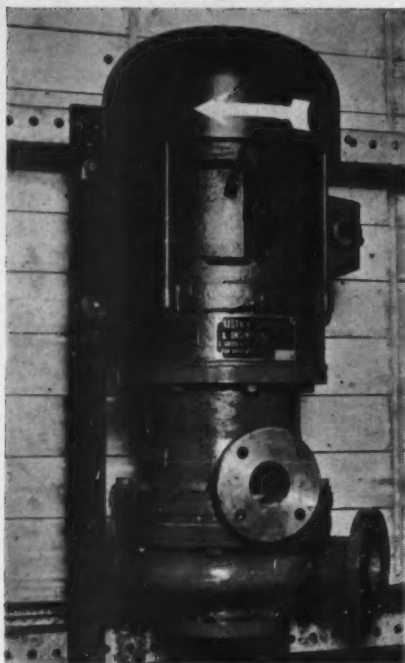
the Association's laboratories at Harlow involves the measurement of the transient characteristics of the centrifugal pump during starting and stopping.² This information is required in connection with pressure surge calculations. An investigation with the aid of a transparent 6-in. suction pipe has been made on the effect of the whirl in the suction branch which occurs under partially throttled conditions. Relatively large positive pressures can be measured at the suction flange and can cause appreciable errors in determining the head-volume characteristics. The effect of bends in the suction branch has also been studied. A transparent test rig for studying the flow conditions in the impeller of a centrifugal pump is under construction.

Seals, packings and joints

The properties of stuffing box seals, their advantages and limitations, are not always

known to those who specify their use; certainly such information is not readily available. As part of an investigation into the behaviour of such seals which the Association is undertaking, a preliminary study has been made of the characteristics of a soft-packed stuffing box for sealing water under continuous running conditions with a true shaft.³ These experiments disclosed much information concerning the interdependence of leakage and friction torque, and indicated that optimum operating conditions occurred when the seal was leaking very slightly. By slackening off the gland so that leakage increased fifty-fold the friction power loss could be reduced to one-tenth; and since even this increased leakage involved negligible power loss, it may well be worth while in some large pump installations deliberately to run the stuffing box much slacker and make provision for disposing of the leakage.

Soft packing seals are unable to tolerate



[Photo: Kastner Evaporator & Engineering Co. Ltd.]

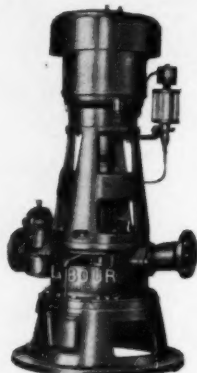
The JP8 glandless centrifugal pump is of the vertical spindle type and in addition to the suction and delivery branches has a branch on the side through which acid is allowed to overflow back to the supply tank when the pump is in operation. An important point of the design is that there is no stuffing box and gland and no rubbing contact between the rotating impeller and the stationary pump casing. In fact no bearing or friction surfaces of any kind are in contact with the acid. As well as eliminating wear and friction this feature is of value when the corrosive conditions necessitate the use of a constructional material of relatively poor mechanical strength. Pumps can, therefore, be made in a wide range of corrosion-resisting materials including 'Keebush,' 'Tantiron,' stainless steel, regulus metal, cast iron, rubber-lined cast iron and P.V.C. suitable for the handling of hydrochloric, hydrofluoric, nitric and sulphuric acids, etc. The pump components are connected directly to the under-side of a totally enclosed motor which can be suitable for A.C. or D.C. electrical supply. The motor is provided with a facing on the side of the frame for bolting the complete unit to a suitable support. This method of construction, it is claimed, reduces the overall height and results in a self-contained unit which occupies the minimum of space. This type of pump is manufactured in sizes ranging from 1 in. to 4 in. capable of delivering from 5 to 600 gal./min. against total heads of up to 100 ft.

more than the slightest amount of shaft whip without leaking profusely, and a device which isolates the effect of whip from the packing itself is now being tested. First results are encouraging and the device promises to provide a successful solution to the particular problem of pumps with worn bearings.

A few simple experiments on special designs of radial-face seals have been made to determine the nature of the interface conditions and the influence of pre-load on friction and leakage. During the course

of these tests, unexpected leakage at high speed was encountered on several occasions; an explanation which accords with industrial experience is suggested in a research report (RR.425), published by the Association in May 1952.

As a continuation of the study of the frictional properties of seal materials, experiments are in progress to investigate the change of static friction taking place when rubber seals remain stationary for long periods. Preliminary results suggest that the friction begins to increase im-



[Photo: British LaBour Pump Co. Ltd.]

Vertical, packingless, self-priming pump, type BG, incorporating an hydraulic seal which is effective only while the pump is running. For this reason the unit must always be placed above the source of supply. It can be made from a variety of metals including cast iron, acid-resisting bronze, phosphor bronze, silicon aluminium, stainless and LaBour R.55 alloy. At 2,900 r.p.m., capacities range from 10 to 200 gal./min. with heads from 60 to 110 ft. At 1,450 r.p.m. a range of 30 to 400 gal./min. with heads from 10 to 75 ft. is possible. Pump sizes at 2,900 r.p.m. are 2 in. and 2½ in., and at 1,450 r.p.m. 2 in. to 5 in.

mediately motion between seal and metal ceases, and continues for a period which may exceed a week. The severity of the sticking seems to vary with different seals, metals, liquids and loads, but no instance has yet been encountered in which the static friction after delay exceeded the coefficient of the surfaces when completely dry.

Reciprocating pumps

The test rig which is being constructed by the Association for investigating the behaviour of self-acting valves on reciprocating pumps has been almost completed and experimental work will be started as soon as the necessary instruments have been assembled.⁴ The motion of the valve will be recorded by an electrical device which is frictionless and adds only little to the inertia of the valve disc. The pressure changes in the cylinder will be measured by means of an electronic recorder able to respond to high-frequency oscillations.

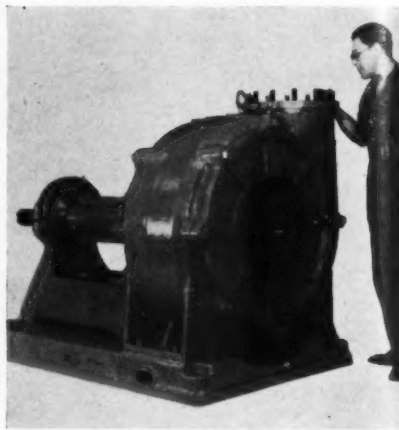
Theoretical work has been carried out on the operation of reciprocating pumps

near top dead centre. A technical note (T.N.427) has been issued by the Association dealing with the minimum pressure in the cylinder immediately before the suction valve opens; this is expected to shed some light on the minimum suction pressure which has to be maintained to prevent cavitation in the cylinder. Experimental work on this aspect will be carried out on the test rig mentioned above.

Experimental and theoretical work on the flow through valves at low lifts has indicated that cavitation is likely to occur between the seal faces, both while a valve is rising and also when the lift is maintained constant. It is hoped to continue this work at a later date.

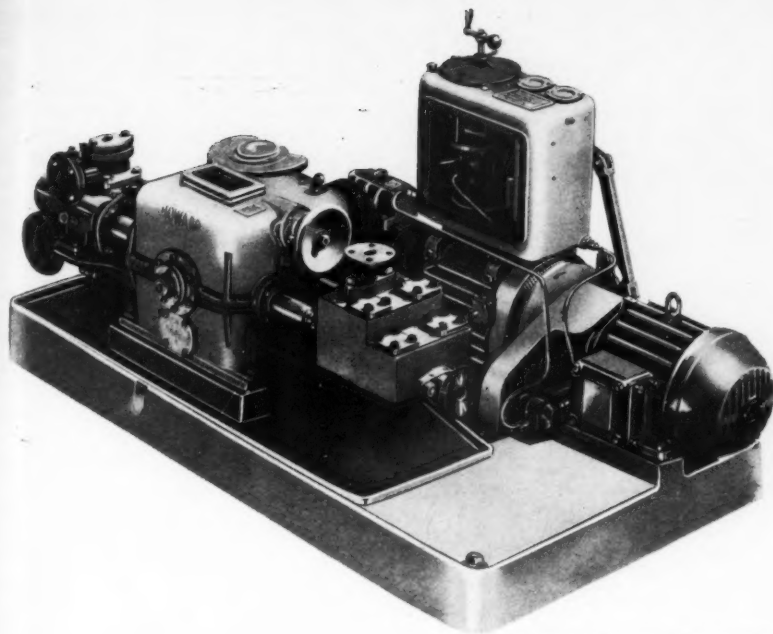
Volatile liquids

The problem of vapour locking in centrifugal pumps is linked closely with allowable suction conditions and pumps designed to handle volatile liquids should be carefully considered in detail by the manufacturer and user. In the author's last review, published in November 1951, the nett positive suction head (N.P.S.H.) problem was discussed briefly and it would not be out of the way to mention once again that



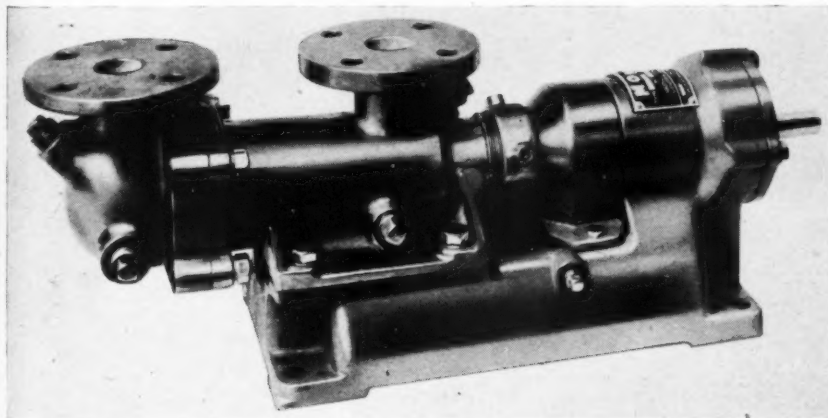
[Photo: Wilkinson Rubber Linatex Ltd.]

Linatex centrifugal pump, 12-in. model, the largest in a range designed to handle up to 3,600 gal./min. at 120-ft. head. These pumps are lined throughout with Linatex rubber to provide resistance to abrasion by solids in suspension and to the corrosive action of a wide range of chemicals. A special feature of this unit is the patented hydrostatic gland which requires no packing. Sealing water at the rate of about 1 gal./min. is introduced into the gland between two Linatex seals which bear on the shaft sleeve. The water lubricates the sealing faces, subsequently flowing into the pump at the hub of the impeller, and washing away abrasive solids. The principal parts of the pump are made in close-grained cast iron, and the high-tensile steel shaft is supported in heavy-duty spherical roller bearings. All parts are interchangeable and replaceable from stock. Another recent introduction is a small diaphragm pump also lined throughout with Linatex rubber. A hand-operated model is in production and a motor-driven unit will also shortly be available. Both types are self-priming and suitable for a maximum suction lift of 10 ft. and a maximum discharge head of 25 ft.



[Photo: Howard Pneumatic Engineering Co. Ltd.]

The Howard Proportionmeter pump is a variable output plunger type, working on the principle of two plungers moving in and out of a pump chamber containing suction and discharge valves. The plungers can move in phase, both moving in and out together, each plunger displacing its own volume of liquid and achieving maximum output; or out of phase, with one moving in while the other moves out, no liquid being displaced through the delivery valve, so that output is at zero. Output may be altered from maximum to zero while the pump is running. The pump is driven by a vertical-spindle electric motor mounted on top of the gear case, which is standardised in four sizes capable of transmitting powers ranging from $\frac{1}{4}$ to 10 h.p. and which contains a worm reduction gear. The model shown is an instrument-controlled Proportionmeter pump equipped to pump two separate liquids in a variable ratio, the total throughput and speed being remotely controlled by a standard instrument control unit attached to a Carter variable-speed unit. The pump is fitted with a normal liquid end to handle liquid A. The end handling liquid B is fitted with a special liquid end in which each cylinder has a suction and discharge valve. There is no connection between the cylinders, and each acts as a separate pump whatever the phase relation between the plungers.



[Photo: Mono Pumps Ltd.]

This Mono H4 pump has its contact parts made of stainless steel, the bearing housing of cast iron, and the stator of rubber or other material, according to the nature of the liquid to be handled. The model in the photograph has $1\frac{1}{2}$ -in. suction and delivery branches. By reversing rotation, direction of flow can be arranged either 'suction' or 'delivery' on gland. The normal speed of 1,450 r.p.m. can be reduced if material to be handled is very viscous or abrasive. Capacities for the H pump range from 60 to 5,000 gal./hr. The pump will operate, and prime itself, with suction lifts up to 25 ft. of water at normal temperature. The capacity is reduced as the suction lift is extended from zero to maximum. Supplied as a stationary or portable unit, the pump is suitable for direct-coupling to standard electric motors, petrol engines or other prime movers or driving by flat or vee belts.

prevention of vapour locking in centrifugal pumps is accomplished by providing sufficient N.P.S.H., sometimes known as 'flow impedance.' This is defined as the pressure head at the pump centreline plus the velocity head at the pump inlet minus the vapour pressure head corresponding to the liquid temperature at the point of measurement.⁵

If centrifugal pumps are to be successful for pumping volatile liquids⁶ certain operating details should be carefully watched, e.g.

(a) Sufficient N.P.S.H. should be available at the pump suction branch. When handling volatile multi-component hydrocarbons the true vapour pressure of the liquid and the pumping temperatures should be allowed for.

(b) Fluctuations of suction pressure due to sudden changes of load and corresponding reduction in pressure should be avoided.

(c) Suction piping should be short and as direct as possible with the minimum number of fittings. Low suction velocities are also desirable.

(d) Stuffing boxes operating under vacuum should be suitably sealed with water or oil.

Rotary pumps for viscous liquids

To pump viscous liquids with a minimum of vibration, noise and reduction in capacity, the pump speed should be reduced as the viscosity of the liquid pumped is increased. Pressure conditions at pump inlet, entrained air or vapour, air or gas in solution and size of pump used also influence the permissible speed for a given viscosity. For example, if a pump running at 100% designed speed with a viscosity of 1,000 Saybolt Seconds Universal (S.S.U.) is required to deal with a liquid having a viscosity of 100,000 S.S.U., the speed may have to be reduced to about half the original speed.

The subject of pumps for viscous liquids is dealt with admirably in a number of interesting publications.⁷

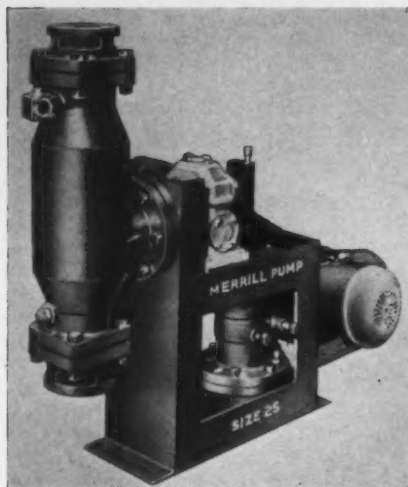
How to order a pump

When ordering pumps for special duties, particularly in the chemical industry, it is essential to provide sufficient information from which a suitable pump design can be recommended.

Specific details of suction conditions, total head against which the pump is to discharge, maximum quantity to be handled, and chemical and physical analyses of liquid to be handled should be given. Interesting information is published from time to time on this subject which affords much guidance to pump users.⁸

Pump maintenance

A picture strip of a most interesting film review on this subject was published during 1952⁹ and is well worth seeing. Pump maintenance ranks in importance with correct hydraulic design, and certainly with pumps for the chemical industry it



[Photo: Merrill Pumps Ltd.]

A hydraulically-operated, tube diaphragm self-priming glandless pump for pumping a wide range of corrosive and erosive chemical liquors and slimes. The unit shown has a capacity of 25 gal./min.

is essential to have a rigid programme of maintenance, particularly with the glands of pumps handling corrosive liquids.

Mechanical seals

The increasing degree of reliability of mechanical seals for the most arduous duties is most marked. This problem of satisfactory shaft seals is being tackled successfully with considerable engineering ingenuity, and a number of publications¹⁰ and articles in the technical press on the subject have appeared from time to time.

New and improved pumps

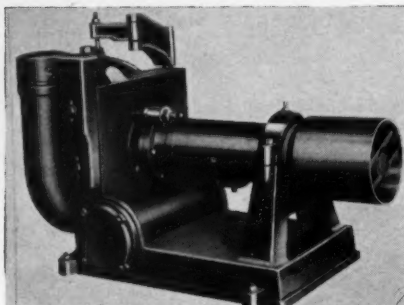
Several new pumps and improved versions of older types have been introduced since the last review. Wilkinson's Rubber Linatex Ltd. have produced a centrifugal Linatex pump which is said to be the largest of its type and which seems well suited to handling large volumes of acid slurries and effluents.

Two vertical packingless self-priming pumps have been introduced by the British LaBour Pump Co. Ltd., who also make a new horizontal self-priming pump.

The Pneu pump is a machine of novel and simple design which is claimed to be capable of handling liquids ranging from water to molten metals. It is compressed-air-operated and works on the positive displacement principle. Units with capacities up to 15 gal./min. are available. The makers, Ames Crosta Mills & Co., also market a stoneware pump for corrosive liquids which will couple conveniently to standard chemical stoneware pipes. They also sell a lead-lined version.

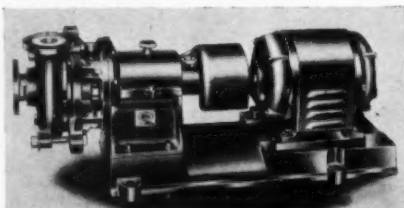
Another new pump from the same firm is the *Simpulscic*. It is a variable capacity unit for acids, alkalis, slurries, viscous fluids and other difficult liquids where pumping at controlled rates is required. Delivery is infinitely variable and can be

regulated from zero to maximum flow either manually or automatically while the pump is in operation and without any interruption in the discharge. The liquid is conveyed in a flexible rubber duct which is completely separate from the mechanical part of the pump and from all metal parts. The pump appears to be ideal for liquids



[Photos: Dorr-Oliver Co. Ltd.]

Wilfley centrifugal sand pump designed to eliminate the problems encountered when pumps with the conventional type of stuffing box are used in the pumping of gritty pulps, slurries, sludges and hot solutions. The centrifugal seal, or expeller, which consists of a revolving member having wings or paddles radiating from a recess in its centre to its periphery, and a stationary member which acts as a wearing plate, is felt to be a great improvement in pump construction. The material being pumped is prevented from leaking out by the centrifugal action of the expeller wings, and any slippage is caught by the projecting groove and delivered to the wings. An automatic check-valve seals the shaft while the pump is not in operation.

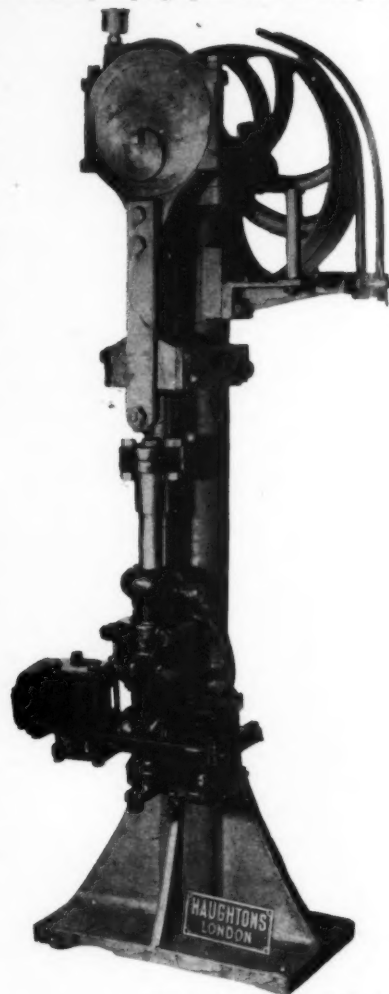


Wilfley heavy-duty centrifugal acid pump for use in chemical and explosives industries. Elimination of the stuffing box is accomplished by a hydraulic circuit at the back of the impeller. When the pump is running, any slippage of the liquid through the labyrinth, formed by the impeller and the replaceable ring in the case plate, is caught and returned to the volute of the case by the secondary or expeller valve of the impeller. It is claimed there is no leakage through the free-running clearance around the shaft while the pump is operating. When the pump is running, there is no rubbing contact between any rotating or stationary parts. When it slows down, the shaft is moved endwise mechanically, thus bringing the conical surfaces of the rotary and stationary seal rings into contact and preventing leaking of the fluid when the pump is stationary. When the pump starts up, the reverse movement takes place. This action is automatic, positive and sure. The wetted pump parts are of heavy sections and ball bearings are of the heavy-duty type. This, together with the elimination of the stuffing box and all rubbing contacts, makes these pumps capable of 24-hr. service without attention.

which have a tendency to encrust and choke the pipes. This is prevented by the operating principle of the pump. Controlled feeding of reagents, as for example, in water and effluent treatment, is another application.

A new and simple design of centrifugal self-priming pump has been made by the Pulsometer Engineering Co. Ltd. in a number of sizes. It does not employ valves or exhausters in its construction. It is only necessary to charge the casing with an initial supply of liquor and from then onwards the pump can be put into operation. Neither suction or delivery valves of any kind need be employed. On running up the pump to speed, air is drawn from the suction pipe, the pump primes and proceeds to discharge.

When pumping operations are complete



[Photo: Haughton's Metallic Co. Ltd.]

Glandless, acid-resisting, plunger pump, especially designed for pumping nitric acid. Made of 'Ironac' high-silicon iron, this standard-size model has a plunger 1½ in. diam. × 4 in. stroke and 1-in. diam. suction and delivery connections. Negligible wear and leakage after long service is claimed for this model, which can be hand driven. Output ranges from 60 to 105 gal./hr. and speed from 30 to 50 strokes/min.

the pump can be stopped and sufficient liquor will be retained in the casing to enable the pump to prime when required for further duty. This pump has a remarkable priming performance; at suitable speeds the pressure on the suction side can be lowered to within 1 in. of the barometer reading when water is used as a priming liquid in the pump. There are no complicated passages or chambers in the pump casing, so that the design lends itself to the use of liquids found in the chemical industry.

A pump made by the Candy Filter Co. Ltd. for small chemical dosing is of interest.

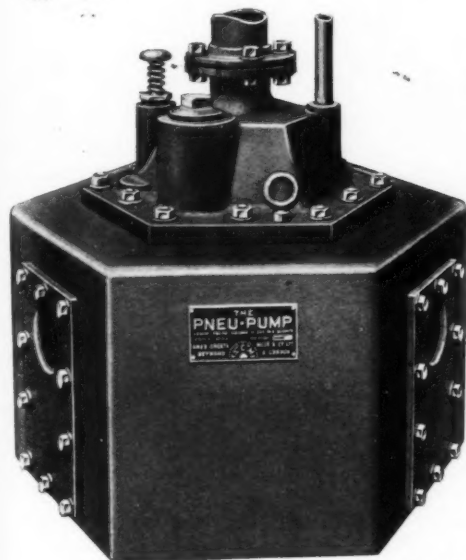
Examples of chemical dosing are: (a) Phosphate solutions to water; (b) chlorine solutions; and (c) detergents.

Another small pump of the positive rotary self-priming type in stainless steel and made by Mono Pumps Ltd.⁴ is of particular interest for pharmaceutical service in dealing with potable liquids, emulsions, etc.

A wide range of chemicals including hydrochloric acid or sodium hypochlorite are dealt with effectively by the *Dexonite* hard rubber centrifugal pump,⁵ manufactured by Dexine Rubber & Ebonite Ltd., for duties up to 10,300 gal./hr. and 100-ft. head. The pump casing is of moulded *Dexonite* in one piece and reinforced with a steel ring, the impeller being of the same material which is also used for packing the stuffing box and for a thrower ring fitted to prevent corrosive liquids from entering the bearings.

The various types of pumps for dealing with acids and other chemicals, slurries and viscous liquors, volatiles, oils, petrol, etc., can be summarised as follows:

- | | |
|----------------------|------------|
| (1) Air displacement | (6) Jet |
| (2) Bucket | (7) Ram |
| (3) Centrifugal | (8) Rotary |
| (4) Diaphragm | (9) Screw |
| (5) Gear | |



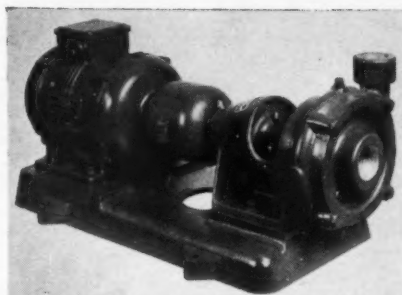
[Photo: Ames Crosta Mills & Co. Ltd.]

The Pneu pump operated with compressed air on the positive displacement principle.

Each has its own particular characteristic and applications, and an appropriate range of sizes appear to be available to meet the needs of the chemical and process industries.

Pumoridge pump index

This continues to be an excellent guide to the design progress and classification of pumps, with special application to the chemical industry. A good deal of useful and up-to-the-minute information is given



[Photo: Girdlestone Pumps Ltd.]

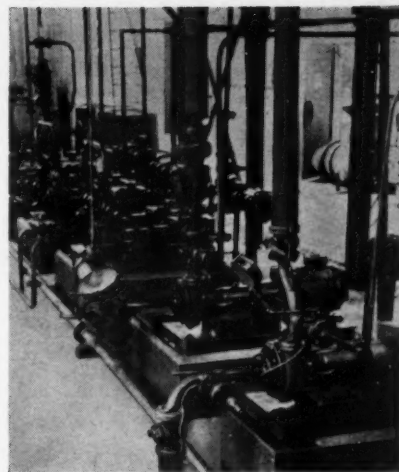
Small, single-stage, ball-bearing centrifugal pump with contact parts of cast iron, bronze or stainless steel. The pump is also available constructed entirely from special metals. The pump shaft rotates in, and is supported by, two externally-housed ball bearings, so that no bearing surfaces are in contact with the fluid being pumped, thus avoiding the possibility of contamination by lubricant. This NR range of pumps is available in sizes between $\frac{3}{4}$ -in. and $1\frac{1}{2}$ -in. Connections are screwed to British Standard pipe thread. Outputs up to 2,500 gal./hr. can be obtained and the maximum head is 95 ft. The stuffing boxes are of unusual length for pumps of these small sizes and can be fitted with lantern rings and pressure greasers or connections for an external water supply to seal the gland. Mechanical seals can be fitted on some sizes. Pumps of similar construction but with connections flanged to B.S.S. Table D are available in sizes between $1\frac{1}{2}$ in. and 4 in.

about materials of construction and general characteristics, two of the most important considerations in the selection of pumps for arduous duties in the chemical industry.

It would be an advantage if a little more information about gland arrangements could be given, as this is a vital part in the successful operation of a chemical pump.

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- ¹CHEMICAL & PROCESS ENGINEERING, 1953, 34, (3), 63, 64.
- ²British Hydromechanics Research Association Fifth Annual Report, 1951-52, 9.
- ³*Ibid.*, 11.
- ⁴*Ibid.*, 11.
- ⁵*Oil & Gas Journal*, April 7, 1952, 131.
- ⁶*Ibid.*, 169.
- ⁷*Ibid.*, 1952, 109, 153, 215. See also, 'Standards of the Hydraulic Institute,' 9th edition, 1951.
- ⁸*Petroleum Processing*, 1951, 6, (9), 974.
- ⁹*Power*, June 1952, 120.
- ¹⁰*Chemical Engineering*, 1952, 59, (1), 152.



[Photo: Sigmund Pumps Ltd.]

For the chemical industry, where temperatures and pressures do not demand special features such as centre-line mounting, and other oil refinery standards of construction, the Sigmund A-N chemical pump has been developed to offer what is required of a good-class, single-stage chemical pump. The design is such that the bearing housing and support frame are not in contact with the liquid and can therefore be made of cast iron while the shaft is completely protected against corrosion by sleeves of hardened or anti-corrosive material. The liquid thrower, apart from serving to protect the bearing housing from liquid handled, has been arranged to fulfil a further important function. It is drilled and tapped to take screws which, when tightened against the reinforced bearing cap, exert pressure to facilitate removal of the impeller and shaft sleeves, thus simplifying what is usually a special tool maintenance job, owing to rust from acids. The pump, a number of which are shown in the photograph, has a robust support frame arranged so that four sizes cover the complete range of 14 units to give heads of 6 to 3,000 ft. and outputs from 8 to 1,500 gal./min. Where the duty is changed or the pump is required to handle a different liquid, only the 'wet' parts of the pump need be replaced. This interchangeability of three or four hydraulic sections to each frame offers advantages both in initial outlay and in meeting variable duties. Depending on the duty for which the pump is required, those parts of the pump coming into contact with the liquid are made of alloy cast iron, chrome nickel steel, special bronzes, high-nickel alloys, cast steel, silicon aluminium, monel or chrome steel. The stuffing box is designed for air or water cooling, soft packing or mechanical seal, and the split gland has a tapped connection which can be used for smothering, cooling down liquids, condensing vapours from the stuffing box or for heating. Grease sealing can be easily effected.

Future Reviews will deal with *Evaporation, Crystallisation, Ion Exchange, Distillation and Catalysis.*

Among articles scheduled for publication are 'Production and Uses of Germanium,' 'New Coal Hydrogenation Plant' and 'Synthetic Liquid Fuels.'

Demineralisation of Salt Waters

I. POTENTIAL SEPARATION PROCESSES AND PHENOMENA

A programme to co-ordinate and stimulate research and development of processes for making salt waters of all kinds fit for drinking and irrigation, has been started by the United States Department of the Interior. Potential processes and energy sources are described in a preliminary brochure in which mention is also made of the possibility of mineral by-products resulting from certain processes. Since demineralisation methods are obviously of chemical engineering interest, we present below the summary of the separation processes given in the brochure. The discussion of potential energy sources for demineralisation will be published in a later issue.

THE need for additional fresh water in many areas throughout the world, and the economic, social and military benefits to be realised from the development of means for providing fresh water to cities, industries and lands suffering from water shortage are abundantly clear to all who have considered the problem.

In recognition of the need and potential benefits, and after extensive hearings and studied consideration, the Congress of the United States reached the conclusion that the present and future demands for new sources of fresh water justify a development programme for this purpose. Accordingly, the 82nd Congress authorised the initiation of one phase of that programme which is directed to the development of new sources of fresh water from saline waters. In enacting that law and in making the present appropriation of \$125,000 to initiate the programme, the Congress indicated its hope that private capital would be attracted to finance much of the research that would be necessary to develop suitable processes.

The objective of the current Saline Water Research Programme then, as authorised by the Congress, is to co-ordinate and stimulate research and development of economically feasible processes by which saline waters of all kinds may be made useful for human consumption, municipal, industrial, irrigation and livestock uses. The reclamation of the many surface and underground mineral waters of inland areas, including the ever-increasing saline return flows from expanding irrigation, takes its place equally in the programme with the development of processes for converting sea water to fresh water.

As a first step in the formulation of a comprehensive programme, which is limited only in the extent to which the Federal Government will participate financially, the officials concerned with the Saline Water Programme have issued a brochure intended to summarise information on demineralisation of saline waters, and to present an outline of physical, chemical and electrical processes and phenomena, and of energy sources, which might be used or developed for this purpose.

In keeping with the principle that a possible key to the development of low-cost demineralisation processes lies in the

use, re-use, conservation and reduction of energy required in any applied separation process, considerable attention is devoted to the development of energy sources for this purpose. As many potential demineralisation processes such as solar evaporation, marine thermal difference plants and others depend upon the development of new or little used sources of energy, it is clear that a significant part of the saline water demineralisation research programme must be devoted to development of such energy sources. In order that the list may be complete, all known sources of energy that might be used for this purpose are included. However, research in and development of conventional energy sources—such as hydro-electric power—is not a part of this programme. Further, the research and development in the non-conventional energy sources will be confined to that which relates to demineralisation, the development and use of such energy for other purposes likewise not being an objective of this programme.

The inclusion of various processes and phenomena does not imply that each is thought to be feasible nor that it will necessarily constitute a part of the research and development programme. All are included in order that the outline will be as nearly complete as possible, and for the express purpose of stimulating scientific thought. The discussions of the several processes and phenomena are intended only as explanations of the probable or possible relationship to the demineralisation of water, and are by no means exhaustive.

Each recipient of the brochure who has a genuine, scientific interest in the programme is invited to assist by advising of:

- (1) additional processes or energy sources which he feels should be considered;
- (2) research areas, if any, in which he is qualified and would desire to participate; and
- (3) financial support available to him for such research.

Based upon additional suggestions which it is hoped will be made, a revised outline of processes and energy sources will be prepared which will be considered as exhaustive of the subject at this time. The research programme will be based upon the subjects included in that final outline. Apparent feasibility of the several

processes, and the extent of attention already being devoted to the development of each, will form criteria for determining the order in which new research should be undertaken.

There is no thought that the needs can or will be met by the development of a single process to serve all purposes. The great variation in mineral waters and in the uses which may be made of the demineralised water suggest that various processes will be needed in order that each may attain maximum economies for a given purpose. Already, for example, evaporation processes suitable for certain shipboard use are available, but these are not suitable for many other purposes.

Economic aspects

As a guide for the economies which must be attained before demineralised water can compete with other water sources, surveys have shown that charges for irrigation water from private irrigation districts in the United States range from a few cents an acre-foot to as much as \$39 in certain highly productive areas. The maximum charge for irrigation water from the Bureau of Reclamation is \$25 at one project in California, with the vast majority between \$1.50 and \$6. For untreated and undistributed municipal water, charges in the U.S. range from a few dollars per acre-foot to as much as \$115 or more, with the average between \$50 and \$75. The cost of industrial water is much more variable, and surveys are only now under way to determine prevailing costs and quantities, and future demands.

The total economy of any process consists of the energy cost, the capital investment and the operation charges. All three must be included, although too often investment cost is omitted from the calculations. Processes by which fresh water can be produced from sea water for which this total cost is competitive with other sources of water in the continental U.S. have not been developed.

By-products

There have been suggestions that the production of marketable by-products of separation processes might provide a revenue to offset other costs sufficiently to justify early production of fresh water in large quantities at competitive costs.

Industrial processes have been developed for extracting one or more minerals from sea water. In most of these processes, no effort is made to combine the production of fresh water with that of the chemicals. Although the limited demand for such minerals might preclude their consideration in defraying the cost of fresh water in large quantities, if processes can be developed by which several minerals can be extracted at one time, their value and demand might be such as to reduce the cost of the water by that small amount necessary to attain economic feasibility.

It seems entirely possible that marketable electrical energy might be developed as a by-product of certain demineralisation processes.

Saline water is a relatively simple system of inorganic salts in water. As such, it possesses certain physical and chemical properties which determine the various phenomena by which the salts may be separated from the water. As might be expected, the system is comparatively stable since the water itself and the inorganic salts dissolved in it are among the more stable compounds. Because of this stability, separation of saline solutions requires relatively large quantities of energy.

In every process in which a system is separated into its components there is a certain minimum quantity of energy which is required for the separation. This minimum energy requirement is determined from basic scientific (thermodynamic) principles covering natural processes generally. This requirement for separating the salt from sea water has been computed at 2.8 kwh. (3.8 h.p. hours) per 1,000 gal. This figure is independent of the type of separation process, since it represents only the energy necessary to separate salt from water.

In any applied process, whatever the materials to be separated may be, energy requirements always are much in excess of the thermodynamic minimum because of other energy demands and inability to attain the theoretical separation minimum. Likewise, in the separation of salts from water, the energy used in practical applications considerably exceeds this minimum, because of these other energy demands, such as those required for evaporating the water itself, heat and friction losses, electrical resistances, etc. The total energy requirement of any process depends upon the extent to which these extraneous demands can be reduced.

I. PHYSICAL PROCESSES AND PHENOMENA

(a) Vaporisation

The process of vaporisation applied to demineralisation consists of evaporating a part or all of the water from the saline solution and subsequent condensation of the mineral-free vapour—the process known as distillation. The products of distillation are pure water and either a

Table 1. Potential Separation processes and phenomena

I. PHYSICAL PROCESSES AND PHENOMENA	
(a) Vaporisation	
1.	Vapour-compression distillation
2.	Single- and multiple-effect evaporation
3.	Flash evaporation
4.	Flash-type multiple-effect evaporation
5.	Combination compression distillation and multiple-effect evaporation
6.	Critical pressure devices
7.	Superheated steam
8.	Underwater combustion
9.	Temperature differences
(b) Crystallisation	
1.	Freezing of water
2.	Crystallisation of salts
(c) Sublimation	
(d) Adsorption	
1.	Adsorption of water
2.	Adsorption of ions
(e) Diffusion effects	
1.	Thermal diffusion
2.	Gravitational diffusion
(f) Ultrasonics	
(g) Osmosis	
1.	Molecular oil films
2.	Biological membranes
(h) Immiscible liquids	
II. CHEMICAL PROCESSES AND PHENOMENA	
(a) Ion-exchange	
(b) Hydration	
(c) Precipitation	
III. ELECTRICAL PROCESSES AND PHENOMENA	
(a) Electro-ion-migration	
1.	Electrolysis—2- and 3-compartment cells
2.	Perm-selective membranes
3.	Electro-gravitational methods
(b) Streaming potential	
(c) Electrostatic effects	
1.	Migration in electrostatic field
2.	Dielectric effects
(d) Electromagnetic effects	
1.	Migration in electromagnetic field
2.	Magnetic susceptibility
(e) Ultra high-frequency currents	

concentrated salt solution or a mixture of crystalline salts and concentrated solution. This is a process in which water is removed from the salts rather than salts from the water. Hence, heat and power requirements are relatively independent of the amount of salts present. This is a characteristic difference between the vaporisation process and most chemical and electrical processes which remove the salts from the water. At present almost all the fresh water produced from sea water is by one of the evaporation methods. Sea-water evaporators aboard ships have been in use for many years. Evaporator installations for producing potable water from sea water are located in Kuwait, Bermuda, Aruba, and Curacao, Johnson Islands and elsewhere. Much of the development of evaporation equipment has been by the armed services in co-operation with engineering and industrial firms.

1. Vapour-compression distillation. In this process, salt water is evaporated at atmospheric pressure and the vapour

compressed to raise the pressure of the steam about 3 p.s.i. and the temperature correspondingly to about 222°F. The compressed steam is returned to the heating side of the evaporator tubes to heat more of the brine from which the original vapour was formed. Since the brine in the evaporator boils at 213°F. a temperature differential of about 9°F. exists between the compressed steam and the boiling brine, which permits heat transfer back to the brine. Substantially all of the latent heat of the compressed steam is used in maintaining evaporation of the brine solution, and condensation of the compressed steam occurs directly in the steam chest forming the distillate product. Thus no separate condenser or cooling water is required. The fact that no cooling water is needed for the vapour compression unit is an important difference from an engineering standpoint between it and the multiple-effect evaporator.

This process has been intensively developed since about 1940, although it had been in use for many years previous. At present, 1 lb. of fuel oil will evaporate nearly 250 lb. of water in a clean vapour compression unit, and there is still a possibility for further improvement in fuel economy. The formation of scale has always been a problem in brine evaporators since it reduces the efficiency of a unit materially and periodic shutdowns are required for its removal. Both the Navy and Army have investigated methods for removing and reducing the amount of scale formed. The cost of water produced by this method has been estimated at \$400 per acre-foot. About 40% of the total is for fuel.

2. Multiple-effect evaporation. In the first stage water is evaporated at a given pressure. The vapour is led to a second compartment where additional water is evaporated at a lower temperature under a small vacuum by use of the heat in the steam from the first effect, which is there condensed. In turn progressive evaporation of water is carried out in successive stages each at lower pressure and temperature. This method has been under extensive commercial development for many years. Recent advances concern scaling, corrosion and size of equipment. The process has been adapted for use in large capacity equipment. Fuel costs alone for triple-effect evaporation have been estimated at \$0.60 per 1,000 gal., with a total cost of perhaps \$1.60.

3. Flash evaporation. In flash evaporation, water at a given pressure and temperature is released into a chamber of slightly lower pressure where the liquid flashes into vapour, and subsequently is condensed. Most of the salts separate out upon flashing and scaling is thus largely eliminated, although some, particularly the sulphates, may partially separate in the boiler prior to vaporisation. Many flash-type evaporation processes are being studied and proposed at present. Among

other applications flash evaporation may be utilised in temperature difference and multiple-stage processes (see 4 and 9 below).

4. Flash-type multiple-effect evaporation.

A vacuum flash-type multiple-effect distilling plant is based on the progressive heating of sea-water feed to a temperature of approximately 180°F. and the subsequent flashing of it into various successive chambers operating under vacuum. The flash vapour from each stage is condensed by the incoming raw sea-water feed and the consolidation of the drains (condensate) constitutes the fresh water produced by the distilling plant. The incoming sea-water feed is internally heated in successive stages by the condensate cooler, stage condensers and air ejector condenser. The final heating from an external source, before flashing, takes place in the salt water heater. Any heat source, including electricity, or waste heat such as exhaust steam, exhaust gases, diesel engine jacket water, etc., may be used for this purpose.

5. Combination compression distillation and multiple-effect evaporation. There have been suggestions that increased economies might be obtained from a plant utilising both of these principles in one operation in connection with a steam power plant. Research and development in this area is clearly needed.

6. Critical pressure devices. At very high pressure and temperatures—3,200 p.s.i. and 700°F.—water reaches a critical condition in which there is no distinction between gaseous and liquid state. It has been suggested that a separation of salt from water at this critical pressure would possibly require little energy. Reports have been made of such developments abroad, and at least one United States patent (2,520,186) has been granted for this purpose. The energy required to reach this critical pressure is obviously great, and proof of any total economies in such a method is absent.

One such device makes use of this phenomenon, but its applicability to salt-water separation is not established.

7. Superheated steam. One single-effect evaporation device in which steam is superheated to 1,200°F. with pressure held to less than 2 atm. by forced circulation of the steam, has been reported as requiring no shutdowns for removal of accumulated solids. The use of such superheated steam in stage evaporation for salt-water separation has been suggested and, as the device has been reported to be useful with liquids of high density, it has been suggested that the brine from other processes might be reclaimed by this method. Practicability of the principle for these purposes has yet to be demonstrated. The need for considerable research and development is indicated.

8. Underwater combustion. Although not a separation process in itself, underwater combustion of natural and other

gaseous fuels, including hydrogen itself, has been suggested as a means of eliminating scale formation and heat losses at transfer surfaces. Further development is indicated.

9. Temperature differences. Where a source of warm water and another of colder water are available it is possible to evaporate the warmer water under reduced pressure and to use the colder water for condensing the vapour. The energy required is that to maintain the reduced pressure. A plant utilising this principle can be used as a source of steam for generation of electric power by interposing a simple turbine wheel between the source of vapour and the condenser. The power in turn may then be utilised to provide the reduced pressure. Thermal difference plants can be used wherever such differences exist, but are most often considered for use in the ocean where warm water and colder water from greater depths occur nearby. A small plant of this type was built in Cuba in the late 1920s, but it proved unsatisfactory because of variable ocean currents. Another is under construction at Abidjan on the Ivory Coast of French West Africa with a designed capacity of 10,000 kw. of electrical energy and 150,000 gal./day of fresh water.

It has been suggested that the heat of cooling water discharged from steam power and other industrial plants could be utilised by this principle, salvaging heat energy now wasted.

For solar evaporation see solar energy, part 2.

(b) Crystallisation

Formation of a solid crystalline phase from a liquid solution is well known as an industrial separation process. Applied to saline water the procedure would consist of crystallising either salts or pure water from the solution. It has been found that salt water is included within the mass of ice crystals produced from saline water. Methods of excluding such salt water have been studied. It is possible that some of the recent work on nucleation theory and nucleation catalysis may be applied to the production of ice crystals in such a way as to limit salt inclusion.

Methods of freezing water into an ice-water slush, ice sheets and fine crystals have been proposed. A recent cost estimate gives a figure of \$400/acre-foot. Natural freezing might possibly be utilised in some localities and would reduce this figure considerably. Since the latent heat of crystallisation of water is about one-seventh that of vaporisation, separation by freezing would appear to offer certain opportunities for economies in energy requirements. If, in turn, low cost energy, such as solar energy, can be developed for refrigeration purposes, the high cost occasioned by the many mechanical inefficiencies inherent in most refrigeration systems might be largely compensated. Then, if improvements can be achieved in refrigeration even closely

comparable to those already made in evaporation processes, it would appear entirely possible that a low cost process for demineralisation by refrigeration might be developed. Some basic and considerable applied research is indicated.

(c) Sublimation

The fact that solids have definite vapour pressures is well known; transition from solid to gas and *vice versa* occurs frequently. The existence of the vapour pressure of a solid presupposes its vapour pressure in solution. The vapour pressure of such a material as salt in a water solution is so small as to be difficult if not impossible to measure at room temperature. However, at very high temperatures it is possible that the vapour pressure may become appreciable. A mechanism by which separation might be achieved is not known. There are data on the phase diagram of the system NaCl-water-steam at high temperatures and pressures which indicate the existence of NaCl in the vapour phase in equilibrium with a concentrated brine.

(d) Adsorption

The presence of fields of force on the surface of a solid, when the solid is in contact with a liquid or gas, results in the retention of a portion of the liquid or gas upon the solid. Application of this phenomenon to the demineralisation of saline water could involve the adsorption of either water or saline constituents, thus effecting a separation.

The adsorption of water on materials such as silica gel has been suggested. However, the volumetric requirements to produce a large quantity of water has discouraged the use of this method. Other desiccants such as polyethylene glycol have been developed and an investigation of other materials available might be fruitful.

Some mention of the adsorption of ions on a surface has been found in the literature. Specific adsorbents for all materials present in saline water are not known but may exist.

(e) Diffusion effects

The rate of passage or diffusion of a gas through a porous membrane is influenced by its molecular weight. Gaseous diffusion has been used in the separation of isotopes to a considerable extent. In liquid solutions perhaps the most applicable method is that of thermal diffusion. A vertical column of solution containing a heat source along the axis undergoes a concentration of the most dense constituents at the bottom. Mixtures of several substances will show some selectiveness, the least dense constituent becoming concentrated at the top of the column.

A proposed method whereby the upper half of a two-compartment unit is exposed to radiation from the sun and the lower half, separated by a canvas membrane, is cooled in the ocean is reported in the

literature. No data on extent of separation or temperatures employed are given. Gravitational diffusion can occur in electrical cells, and is described under electro-gravitational methods.

(f) Ultrasonics

Vibratory motions of frequencies exceeding the limit of hearing (approximately 20,000 cycles/sec.) and extending to millions of cycles a second, are those falling within the usual meaning of the term 'ultrasonic.' The effects of ultrasonic and other high-frequency phenomena are in general applied as a means of keeping a material in suspension. However, tremendous accelerations of molecules are involved—as high as 12,500 miles/sec.—which bring about changes in molecular structure and other properties. This may be applicable directly to the separation of salts from water, or as a means of accelerating or facilitating separation by other processes. Several methods using ultra high-frequency for preventing scaling in connection with boiler water treatment have been reported.

(g) Osmosis

1. **Molecular oil films.** The development of salt-repelling osmotic membranes based on ion repulsion at a water-oil boundary has been suggested as promising economical production of fresh water from sea water at low cost. A theoretical study has been made and some physical research appears to be in order.

2. **Biological membranes.** It is well known that certain biological membranes and organs separate and isolate various components of ingested or inhaled substances, including salt water. It has been suggested that low energy requirements and high efficiencies apparently prevailing in such biological separations may justify examination of the use of these membranes for demineralisation.

(h) Immiscible liquids

Separation of solids from water based on their differential solubility in liquids immiscible with water may have some utility in pre-treatment processes.

II. CHEMICAL PROCESSES AND PHENOMENA

(a) Ion-exchange

Ion-exchange as applied to demineralisation of water involves the removal of both the cation and anion of the dissolved salt by exchange for a less objectionable ion in the exchange material. As conventionally operated, two exchange resins are required, one for cation removal and one for anion removal. The cations are replaced by hydrogen ions producing acids with the anions remaining in solution. These acids are in turn exchanged or absorbed, as it is commonly expressed, by the anion exchange material. The net result is the formation of an amount of water equivalent to the salts removed. The quality of the

fresh water produced is equal to that produced by distillation. This demineralisation process should not be confused with softening of water by ion-exchange in which only the cations calcium and magnesium are exchanged for sodium, leaving in solution an equivalent amount of sodium salts with no net decrease in the total dissolved materials.

In this demineralisation process, for every equivalent amount of salt removed a corresponding amount of regenerating chemical must be supplied. Therefore, sea water with its high salt concentration requires tremendous quantities of regenerants. In addition, large amounts of fresh water are required to flush the system after regeneration. For this reason demineralisation by ion-exchange is better adapted economically to waters of low saline concentration than to sea water, and wide commercial application has already been made in this field. Conversely, with equipment available today, the distillation process, since its fuel and power requirements are relatively independent of the salts present, appears to be better adapted economically to sea water and waters of high saline concentration. Comparative studies have been made to determine the range of salt concentration to which each process is best adapted from a cost standpoint.

Efforts have been made to reduce to a minimum the amount of regenerants and rinse water required. Among these developments are the four-bed system, recycling of the flow and mixed-bed de-ionisation. Recently these improvements have been further developed by a process called the counter-flow method of partial demineralisation. The exchange beds are regenerated in a direction opposite to the water flow. Since only partial removal of the salts is sought, a higher regeneration efficiency can be obtained by careful control of the process and regeneration of the resins in a direction opposite to the flow of the water.

(b) Hydration

Formation of insoluble hydrates by the addition of chemical substances to saline water may have some applications in demineralising water. Water may be recovered by changing the process variables such as temperature or pressure. Withdrawal of water from saline solutions by hydration of chemical compounds and its later release as pure water by dehydration is a possible method.

These applications to demineralisation remain to be investigated.

(c) Precipitation

Methods utilising chemical precipitation of mineral materials in saline water are used extensively in water treatment plants for industrial or potable use. However, the quantities of chemicals required for precipitation are approximately equivalent to the quantities of salts removed. For

large-scale demineralisation of sea water the quantities of treatment chemicals would be very large.

Recent advances in chemical precipitation have consisted principally of improvements in existing processes and development of emergency life raft equipment. The cost of water produced from sea water by this method has been estimated as high as 2 cents a gallon or about \$7,000/acre-foot. However, in special applications for removing specific components, such as the degasification of bicarbonates, chemical precipitation offers some promise.

III. ELECTRICAL PROCESSES AND PHENOMENA

(a) Electro-ion migration

When an electric current is transmitted through a saline solution the cations of the salt molecules in the solution migrate toward the cathode and the anions toward the anode. This phenomenon is known as electro-ion migration. Several quite dissimilar devices have been introduced which provide means of causing the moving ions to unite with other ions within the cell and be washed aside in a reject stream, while an ion-depleted stream is drawn off separately. The theoretical minimum energy required to cause separation of the salt from normal sea water is about 3 kwh./1,000 gal. This can only be approached in an electro-ion migration cell as flow rates approach zero. Practical electro-ion migration processes employing relatively high rates of flow are needed. Such processes appear to offer good opportunities for economy of operation. Much research is needed to perfect devices already in laboratory use and to develop new means of utilising this principle.

Particularly needed is basic research to determine the probable lower limit of approach to the theoretical minimum energy requirement that may be attained by electro-ion migration processes. This probable lower limit has been variously estimated at from fifty times to as low as five times the theoretical minimum.

An interesting possibility is the differential separation by electro-ion migration of the various ions present in a solution. As the mobility of various ions under influence of an electric current varies, it would appear reasonable to expect that processes and membranes may be developed by means of which individual minerals may be selectively extracted or caused to remain in solution. Production of valuable minerals, or control of salinity of the water to facilitate special uses, such as irrigation, may become possible by such processes.

1. **Electrolysis** (two- and three-compartment diaphragm cells). Electrolysis of a saline solution generally results in the evolution of hydrogen at the cathode and either oxygen or chlorine at the anode. The catholyte becomes basic due to removal of hydrogen ions, and the anolyte becomes acid. Consequently, hydroxides

of the elements such as calcium and magnesium precipitate in the cathode chamber. The precipitation of calcium and magnesium salts at the cathode has been used as the basis for a water-softening process. In one water-softening unit a porous diaphragm separates the anode and cathode solutions forming a two-compartment cell. The calcium and magnesium precipitates are removed from the catholyte effluent by settling and filtration. The anolyte solution is discarded.

The same type of cell is adapted to demineralisation if constructed as a three-compartment cell. In this case, two porous diaphragms are used, providing a central compartment separated from the electrode solutions. Feed water enters this central compartment and the dissolved salts are progressively removed during the electrolysis forming demineralised water after sufficient treatment.

The three-compartment porous diaphragm cell was studied quite extensively both in Europe and the United States prior to the development of ion-exchange demineralisation processes. In the earlier equipment, demineralisation was limited to fresh waters. The purpose generally was to obtain water to be used in lieu of distilled water.

Operating results on sea water with this cell are not available. However, cost estimates have been made on the three-compartment cell and have been reported at 90 cents/1,000 gal. for power alone. Power costs are high because an electrochemical equivalent of current must be used for each equivalent of salt removed.

2. Perm-selective membranes. The combination of perm-selective membranes and electrolysis as a process for demineralisation of water is a recent advancement. During the formation of any quantity of product in an electrolytic process, equivalent amounts of ionic constituents are transported into the electrode regions. This same quantity of material must pass through any plane parallel to the electrodes. If in an electrolytic cell the space between electrodes is divided into compartments by a large number of membranes which possess the property of permitting the passage of either a cation or anion, but not both, and if the anion-permeable and cation-permeable membranes are arranged alternately, a method of demineralisation is obtained. By such an arrangement salts will be removed from alternate compartments, and transferred to adjacent compartments from which they cannot migrate electrically but may be removed by hydraulic action. Hence the flow from these alternate cell compartments will consist respectively of water of a reduced mineral content and an enriched brine. The number of equivalents of salts removed from the ion-depleted water and transferred to the brine flow is a function of the electrolytic current employed and the number of compartments within the cell. The amount of current needed for

a given amount of demineralised water is reduced as the number of compartments between the electrodes is increased. The quantity of electric power required, then, for removing a given quantity of salts is a function of the number of compartments, the resistance of the unit and the rate of hydraulic flow.

In recent years considerable progress has been made in the development of membranes from ion-exchange materials possessing the property of selective ion permeability. Only recently have the perm-selective membranes prepared from ion-exchange resins been combined with an electrolytic cell as a process for demineralising water. Although commercial units are not yet available, laboratory units have been built and several publications are available. The cost of such a process has been estimated at from 10 cents to 20 cents/1,000 gal. for sea water, using 3 mil power.

3. Electro-gravitational methods. The relationship here is one of diffusion of more dense materials through a column of liquid. The separation of ionic materials in this way may be possible. One method termed electro-gravitation introduces a reversible electrical cell into the column. If there is a common ion present in the cell and in the liquid, transfer of the ion across the cell results in a net gain of the common ion at one electrode and a net loss at the other. Ions of opposite sign are attracted to the electrode in which the net gain of the common ion occurs. This results in a solution of greater density than the bulk of the liquid and hence a convection current is created. Solutions containing various ions will show some selectivity due to different ionic mobilities. The electric current is reversed repeatedly so that the active solid material involved in the electrode reaction is used over and over again. For continuous desalting, the raw water might be fed centrally into the cell with fresh water issuing from the top and concentrated reject from the bottom.

(b) Streaming potential

When a liquid is in contact with a solid, a stratification of charges forms. When the liquid is moved with respect to the solid, the shearing action produces an electrical potential (the streaming, or electro-kinetic, potential). Application of the streaming potential phenomenon to the demineralisation of saline water is pictured as the forcing of the solution through a porous membrane where the electro-kinetic potential is created. By appropriate construction of the membrane a positive or a negative potential is created. Such a membrane would bar inflow of ions of the same sign while permitting those of the opposite sign to pass.

(c) Electrostatic effects

Ions in solution are charged particles and as such should be influenced by electrostatic fields. Charged particles in

an electrical field are attracted toward the region of opposite charge. A charged material would possibly attract particles of the opposite sign until the charge is neutralised. Reversing the charge on such a neutralised material would result in forcing these ions from the surface. The existence of ions of a single sign separated from the ions of opposite sign in any field, whether electrostatic, or electromagnetic, brings into play attractive forces between these ions which are tremendous.

No applications of migration of ions in an electrostatic field to demineralisation are known to have been developed. Basic and applied research are indicated.

The dielectric constant of solutions of salts varies with concentration and frequency of the applied field. Applications to demineralisation, if any, have not been demonstrated.

(d) Electromagnetic effects

Charged particles in motion have magnetic fields associated with them that may interact with applied magnetic fields. A force component is impressed on an ion in a magnetic field which is at right angles to both the field and to the direction of flow. Such a force tends to move the ion from the field. It is noted that the problems of the great attractive forces between ions in solution tends to oppose any applied force.

A bar of a paramagnetic material will tend to align itself so that its length is parallel to a magnetic field, while a bar of diamagnetic material will tend to align itself so that its length is 90° to a magnetic field. There have been suggestions toward the utilisation of differences in magnetic susceptibility of a solute and solvent for separation of the two. Some research may be justified.

(e) Ultra high-frequency currents

In a laboratory-scale model of a device which has been demonstrated, an ultra high-frequency electrical field is imposed across a tube of salt brine of high concentration, causing flocculation of certain dissolved solids. No technical reports have been made available, no patents have been disclosed, and the basic principles involved were not reported. Some research appears desirable if only to repeat the experiment on a more scientific basis, and later perhaps to establish the fundamental principles involved and the energy flow-demineralisation parameters, if any.

Energy sources for demineralisation including chemical, solar, nuclear, marine, wind and geothermal energy, will be discussed in the second part of the article.

Melamine plastics. The first production of melamine in the U.K. has been undertaken by the British Oxygen Co. Ltd., who have now issued three technical bulletins and a specification for the material.

Acid Recovery at a Solvents Plant

THE use in a modern oil refinery of the sulphur derived from crude petroleum was surveyed and discussed by Dr. J. C. Edgar, of the Shell company, at a meeting of the Institution of Chemical Engineers in London recently. His paper was called 'The Use of Sulphuric Acid in a Totally Enclosed Reaction System.' He first described the recovery of sulphur from H_2S and the manufacture of sulphuric acid at the Stanlow plant of the Shell company (see *CHEMICAL & PROCESS ENGINEERING*, July 1952, 365-366). He then said that, generally speaking, acid is used for three major purposes. Part is used for the acid treatment of lubricating oils, transformer oils, medicinal oils, etc., and this results in the production of heavy acid sludges. At Stanlow, a sludge decomposer is now being installed in which the sludge is decomposed thermally by direct contact with hot coke.

The second major purpose for which sulphuric acid is used is in the manufacture of synthetic detergents. Here the sulphate ion leaves the process as part of the product and cannot, of course, be recovered.

The third purpose for which sulphuric acid is used is the manufacture of synthetic solvents. Here there is a very large acid turnover of several hundred tons per day. The acid leaves the system as a dilute solution which is reconcentrated and used again, so that the process embodies a totally enclosed acid system, and additional acid has to be introduced only to make up for losses by pump gland leakage, acid decomposition, carry-over, etc.

Thus in this refinery, by the combination of a sulphur recovery unit, an acid concentrator, and a sludge decomposer and contact plant, the sulphuric acid supply is

entirely self-contained and is independent of outside sources. There is in fact a surplus of sulphur beyond the total requirements of the refinery, and the petroleum industry has been able to sell large quantities of sulphur to other users.

Reconcentration of acid

The two types of concentrator in most general use for weak acids are the Chemico drum-type concentrator and the Mantius vacuum concentrator. The Mantius plant concentrates about 200 tons/day of 100% acid from 50 to 85% w. At Stanlow the Mantius concentrator is used. It consists of an empty steel shell which is heavily lined with lead and with acid-resistant brick. In the centre there is a brick column which supports the roof structure. Inserted radially into the shell are a large number of silicon iron bayonets into which high-pressure steam is passed. The bayonets are installed in banks of five and steam is fed to them in series flow. Vacuum is obtained by means of a two-stage steam ejector set, but this is preceded by a barometric condenser which removes all condensibles, and by a large cyclone separator which removes any entrained liquid before the vapours pass on to the barometric condenser.

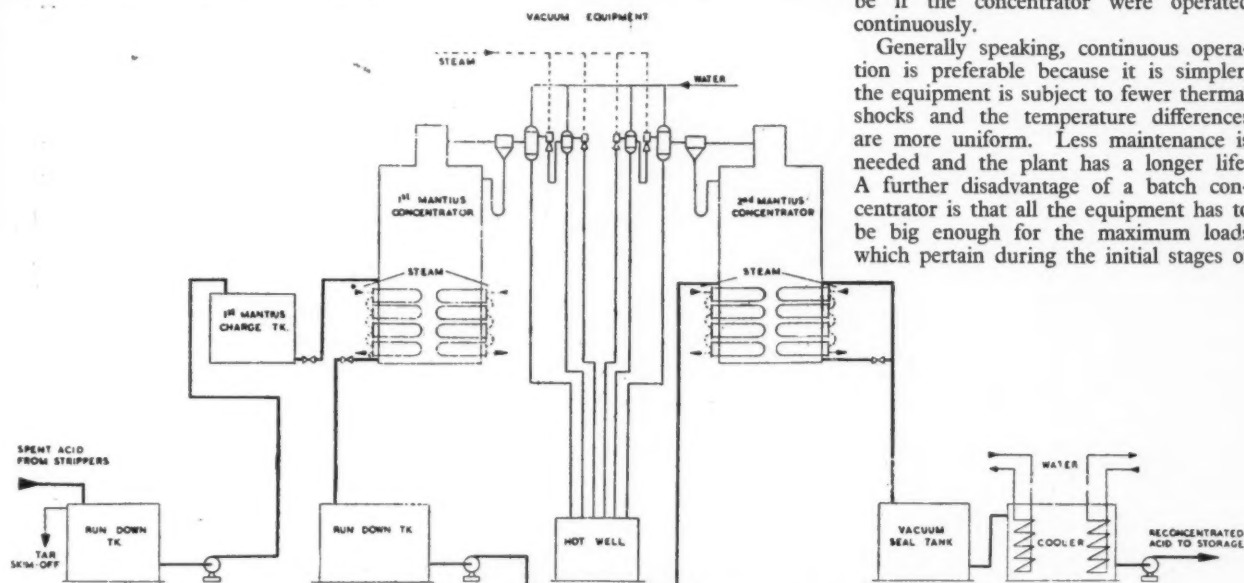
In the acid concentration unit of the Shell solvents plant the spent acid from the strippers is run down into a tank having an overflow nozzle from which tar may be skimmed off. From this tank the acid is pumped to the charge tank of the first Mantius concentrator, into which the acid is drawn batchwise, vacuum being applied to the concentrator. The level is shown by a series of indicating lights which are connected to electrodes located in the con-

centrator at different levels. When the concentrator is charged, steam is admitted to the tubes and the batch is concentrated to the required strength, which may be between 70 and 80% wt. It is then run down to another tank, from which it is pumped to a second concentrator which is operated continuously. The main difference between the batch concentrator and the continuous concentrator is that the latter is divided into four separate compartments by walls radiating from the central column. Each wall is slightly lower than the preceding one so that the acid flows into the first compartment, overflows from this and into the next, and so on until it reaches the fourth compartment, from which it leaves the concentrator through an overflow nozzle to a small vacuum seal tank. The acid is run down continuously from the concentrator at a strength of 80 to 90% wt., depending on the requirement of the process, to the seal tank, from which it overflows into a tank fitted with lead cooling coils. The acid is pumped from this cooler to storage.

Vacuum is provided by means of the two sets of two-stage steam ejectors, all uncondensibles being first removed in the barometric condensers. Booster jets are provided to pull the vacuum down rapidly in the initial stages, and both concentrators have cyclone separators before the vacuum equipment.

The batch process is used for the first stage in order to take advantage of the very high temperature difference during the initial part of the concentration; at this stage the average mean temperature difference is much higher than the constant mean temperature difference would be if the concentrator were operated continuously.

Generally speaking, continuous operation is preferable because it is simpler, the equipment is subject to fewer thermal shocks and the temperature differences are more uniform. Less maintenance is needed and the plant has a longer life. A further disadvantage of a batch concentrator is that all the equipment has to be big enough for the maximum loads which pertain during the initial stages of



Flowsheet of the acid concentration unit of the Shell solvents plant.

the concentration rather than for the average loads. This may add quite considerably to the capital cost of the unit.

The bayonets which were originally installed for steam heating were made of silicon iron, which gives an overall heat transfer coefficient of about 75 B.Th.U./sq.ft./°F./hr. In order to increase the capacity of the unit, an experimental tantalum bayonet was tested. The tube has a wall thickness of only $\frac{1}{8}$ in., and a very much higher heat transfer coefficient may be obtained, which varies from 600 to 300 B.Th.U./sq.ft./°F./hr., depending on the strength of the acid. The heat transfer coefficient for tantalum falls very sharply with increased acid strength, but silicon iron shows no such marked decrease. This may be due to the fact that the skin temperature is much higher with tantalum tubes, and that the effective temperature difference therefore decreases more rapidly with increasing boiling point than with silicon iron tubes which have a wall thickness of 1.5 in.

The actual external diameter of a silicon iron tube is about 6.8 in., as compared with the 1.5 in. diameter of a tantalum tube; the length of both tubes is about 5.8 ft. The surface areas of the silicon iron and tantalum tubes are 10.31 and 2.27 sq. ft. respectively; the average overall heat transfer coefficients are 75 and 450 B.Th.U./sq.ft./°F./hr. respectively. One tantalum tube can transfer 1,020 B.Th.U./°F./hr., whereas a silicon iron tube can transfer 775 B.Th.U./°F./hr., so that a tantalum tube is therefore equivalent to 1.3 silicon iron tubes. Tantalum tubes can be obtained in clusters of two, three or four, any of which occupy the same space as one silicon iron tube, so, by replacing the latter by quadruple tantalum tubes, a five-fold increase in heat transfer capacity can be obtained.

A tantalum tube is more expensive than a silicon iron tube, but not excessively so when costs are compared on a basis of transferable heat.

Thus, per unit of heat transfer tantalum is about 40% more expensive than silicon iron, but this is offset by the fact that it is not brittle and there is no maintenance problem. Furthermore, it has been found that there is no carbon build-up on single tubes; silicon iron tubes do suffer because carbon builds up on the surface and decreases the heat transfer coefficient.

Tantalum cannot be employed with steam pressures in excess of 150 lb./sq.in., not because the metal cannot stand pressures in excess of this, but because at temperatures much above 370°F. it is attacked by concentrated sulphuric acid.

With 150 lb./sq.in. steam (366°F.) tantalum should be satisfactory and, in fact, a tube has been in service for over three years in 75% w. acid under these conditions and has shown no sign of corrosion.

The concentrators of the Stanlow plant have now been completely re-equipped

with tantalum bayonets, and this has very considerably increased the capacity of the unit and reduced the maintenance cost.

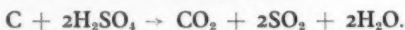
Acid decarbonisation

There are several methods of removing carbon from spent sulphuric acid, but none is entirely satisfactory. Probably the method most widely used is to heat the acid with nitric acid to oxidise the carbon; this is standard practice in some industries, but not all carbon-containing materials can be removed by this process.

A second method is to filter out the carbon, either in plate and frame presses, Sweetland filters, Dorr-Oliver continuous rotary filters, or sand filters. The pressure filtration of acid is never a very pleasant business, and it is difficult to find suitable materials of construction. However, the carbon can be filtered quite easily, and this does offer a process whereby the carbon can be eliminated. It is known that Dorr-Oliver filters are in use for the filtration of acid, and are quite suitable for such a service.

A third process which could be used for the removal of carbon is the oil flotation process developed by the Standard Oil Co. The acid is mixed with a light hydrocarbon oil and a wetting agent and the mixture is allowed to settle. All the carbon is dispersed in the oil phase which can be separated, removed and possibly filtered for re-use; a clear, carbon-free acid is thereby obtained.

The use of pot concentrators has also been considered for the decarbonisation of sulphuric acid, since oxidation of the carbon would undoubtedly occur; however, stoichiometric considerations show that oxidation would be accompanied by a high acid loss—the complete oxidation of 1% carbon would require the reduction of 16% of the sulphuric acid to SO_2 , as is shown by the following equation:



This would make the process uneconomic to operate.

One means of removing carbon which must finally be mentioned is the method of bleeding acid out of the system at such a rate that the carbon content of the acid removed is equal to the total quantity of carbon produced in the reaction system. The carbon content of the acid can be kept constant and small enough for the system to be operated with a minimum of trouble. The acid bleed might have to be as high as 30 to 40% of the total turnover, and it may well be that such a process is not economically feasible, and since the acid system is not totally enclosed the satisfactory operation of the plant may then depend on factors which are not controlled within the plant. The method could function very satisfactorily if there were a nearby fertiliser factory which could use acid containing a little carbon. If ever it is necessary to take a substantial acid bleed from the solvents plant at Stanlow, it can be processed in the sludge decom-

poser and completely broken down for carbon removal and then reconstituted via the contact plant. Even if a bleed had to be taken the whole system would still be independent of outside consumers of acid. Such favourable circumstances do not generally arise. It is therefore preferable to use a positive method of carbon removal rather than to make the satisfactory operation of the unit dependent on factors which are not controlled within the plant itself, and which may depend for their reliability on unpredictable variables such as the rise or fall in the market demand for fertilisers.

Industry's Publications

Reforming plant. Where low-cost high-purity hydrogen or synthesis gas is required, the utilisation of hydrocarbon fuels offers many advantages. In a new illustrated brochure the Power-Gas Corporation Ltd. describes its *P-G Hercules* reforming plant which processes cheap hydrocarbon fuels such as natural gas, propane and refinery tail gases to give synthesis gases or fuel gases of the desired composition. Three processes are depicted: for the production of large quantities of hydrogen in an installation which has been specifically adapted for producing ammonia synthesis gas; the production of alcohol and petroleum synthesis gases for varying ratios of carbon monoxide to hydrogen; and the production of fuel gases of varying calorific values and varying densities, in particular for the production of gas of the same specific gravity and calorific value as town gas.

A news letter dealing with personalities, meetings, policy, inventions, figures, etc., has been started by Evershed & Vignoles Ltd. The *Evershed News* will describe the various uses to which the firm's instruments are put, review current installations of instruments in major industrial plants, detail improvements in design, manufacture and performance and give reports of tests made on new inventions. Occasionally technical articles of general interest on electricity and electronics will be published.

Integral furnace boiler. The type F.H. integral furnace boiler, available in capacities from 40,000 to 250,000 lb./hr. for steam conditions up to 900 p.s.i. and 900°F., is described in detail in publication No. 1525 issued by Babcock & Wilcox Ltd. The boiler is a bi-drum; low-head type and can be arranged for firing by oil, pulverised coal, or a combination of these fuels. The baffling arrangements and the multiple gas passes give a high heat transfer and low leaving temperature; the water-cooled furnace and heat insulation minimises radiation losses and air leakage. Details of cyclone separators, air heaters, ash hoppers and soot blowers are also given. Numerous diagrams of typical sections and installations are included.

Plant and Equipment

Comminuting mill

Extensively used in the U.S., the comminuting mill, a modern development of the hammer mill, has now been introduced into the U.K. by Apex Construction Ltd.

Made of stainless steel, the mill consists of a chamber, the lower part of which holds interchangeable screens. Through the chamber is a shaft carrying a rotor to which a number of hammers, usually swinging, are attached. The mill can be operated with hammers of different types, either a hammer edge or a cutting edge. Material to be processed is fed from a feed pan down a special feed throat or chute to the high-speed blades and the material passing through the screens is caught in receivers, the process being dustless due to the use of an air filter.

In order to control the operating temperatures so that heat-sensitive materials are not subjected to excessive temperatures, water-jacketed feed throats are available; grinding chambers can have side plates and end plates similarly cooled. By rapid removal of fine material produced, the large screen prevents more than the minimum generation of heat. The mill is thus suitable for pharmaceuticals, including antibiotics.

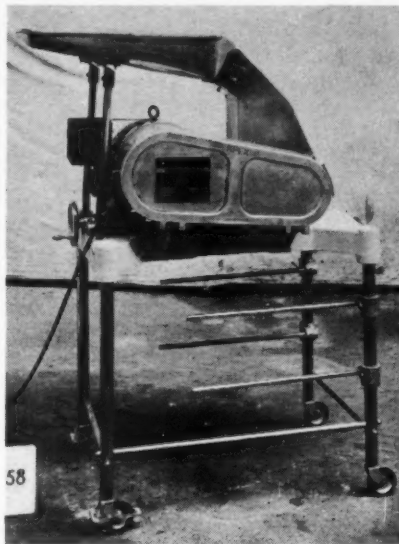
The machine is motor driven, equipped with three speeds, and can be fitted with a variable-speed drive; the rotors are driven at speeds up to 4,600 r.p.m. and higher speeds are available. It is built for power inputs of 3, 5 and 7½ h.p.

Various types of blades have been developed for special uses. Six types of feed throat are available: e.g. single purpose for dry and wet materials, for disintegrating dry materials and for handling dry materials in large quantities; and dual purpose for processing both wet and dry products. Seven types of screens in more than 36 sizes, ranging from 1½ in. to 200 mesh, can be used. These are made in stainless steel or other non-corrodible metals.

Uses in the chemical field include size reduction of materials, size enlargement, dustless pulverising of chemicals, breaking up of agglomerates, mixing and sizing of materials in previously roughly mixed condition, and dispersion of colours, lubricants and other materials through dry, finely divided powders, or of solids and flocs in highly viscous bases, etc.

Temperature control relay

An open-contact relay (type 211) has been developed by Electro Methods Ltd. for use with their series 200 adjustable or fixed-contact thermometer. It is designed to provide efficient temperature control in circumstances where instantaneous reaction of the relay must be given in response to

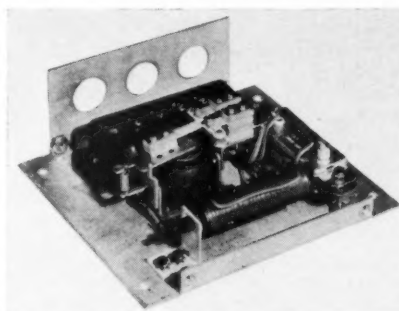


Stainless steel comminuting mill.

the thermometer reaching its set temperature and where it is unnecessary for contacts to be hermetically sealed.

The relay is supplied complete with an associate rectifier and high-wattage resistances. It is capable of switching up to 15 amps at 250 volts A.C. over prolonged periods. In order to safeguard the thermometer, the current of the control circuit is limited to 20 mA. Installation is simple, terminals are conveniently arranged and contact-assemblies are easily replaceable. The relay is particularly well suited for use in incubators where a close temperature-cycle has to be maintained for long periods. Previously, mercury-type relays have been used for this work, but, due to their delicate construction and general inability to withstand rough usage, their service life has been relatively short.

This unit may be used for controlling temperature in incubators, sterilisers, pasteurising or germinating equipment, hot-air cupboards, enamelling ovens, constant-temperature baths, radiation-heating installations and humidity chambers, etc.



Relay for temperature control.

'Micromolecular' still

To distil very small samples of oils that normally defy distillation, Dr. R. P. A. Sims of the fats and oils section, National Research Council, Ottawa, has developed what he calls a 'micromolecular still,' consisting of a tiny glass pan suspended from a quartz spiral. This sensitive spring operates in a vacuum, with a built-in heating coil and a device for measuring temperature. With this apparatus he can separate a single drop of a complicated oil or other material into its various components—and measure the molecular size of each fraction at the same time.

Plastic refractory

M.R. Plastic Mouldable is a super-duty refractory compound of a stiff malleable consistency, supplied ready for use by the Morgan Crucible Co. Ltd. Careful selection of raw materials and new methods of manufacture have produced this plastic mouldable whose main characteristics are claimed to be a very high degree of refractoriness (P.C.E. 33/34), volume stability under high temperatures and loading, and freedom from spalling. It can be used to advantage in places where fireclay or super-duty firebrick have been used, and in certain circumstances is superior to pre-fired high alumina shapes. It can be used in place of special shapes and eliminates the need for cutting and fitting.

It is supplied in air-tight 112 lb. drums ready for use, and each drum contains approximately 0.7 cu. ft. of material. Sketches in a descriptive leaflet (R.D. 34) illustrate the simple method of application. The refractory can be hammered into position with, or without, the use of formers and as it is impossible to 'overram,' it can be used to install linings or make shapes using comparatively unskilled labour.

Electrically-closed filter press

A new filter press has been produced which is closed electrically. The tightening gear is essentially simple, the pressure being readily adjustable. It is claimed that it is impossible to overload the motor or the driving gear. The gear is operated by means of a vertical handle which is moved in whichever direction it is required to move the running end of the press. The whole of the gear is completely self-lubricating and oil-immersed, and the screws run in phosphor bronze renewable nuts, and are fitted with ball thrust bearings where they engage the moveable end of the press. This electrical tightening or closing gear can be adapted to convert most hand operated filter presses with very little alteration.

The presses can be supplied with either recessed plates, or plates and frames, which may be of washing or non-washing type. They can also be supplied with steam heated plates. Makers are Edwards and Jones Ltd., and the selling agents are Donald Leaver Ltd.

World Chemical Industry Expansion

An outline of the development of chemical industries all over the world is given in the Report of the Chemical Industries Committee of the International Labour Organisation, which was discussed at the recent meeting of the Organisation in Geneva. Here is a summary of this Report which gives a unique picture of the economic importance, raw material problems and employment trends in the world's chemical industries.

AS the supplier of almost every other industry and as itself the consumer of basic products, the chemical industry is the pacemaker in most national economies. It is with this basic concept of the chemical industry that the report begins. In many countries, mainly the highly industrialised ones, the chemical industries have grown rapidly to immense proportions; even so they are only in their infancy compared with the prospects before them.

Describing expansion in the chemical industries, the report gives figures for various countries, starting with the United States.

U.S.A.

In that country, the index for general industrial production (taking the 1935-39 average as 100) was 179 in December 1949 and 219 by October 1951. The figures for the chemical industry, whose production indices were exceeded only by those for the machinery and transport equipment industries, were 245 in 1949 and 302 in 1951. For the industrial chemical products branch, which especially influences the expansion of all industrial activity, the figures were 422 and 563, showing an unprecedented volume of production.

The U.S. chemical industries are the largest in the world, being responsible for about one half of total production. They are also first in foreign trade. However, because of increased home demand, exports dropped from \$774.1 million in 1949 to \$725.1 million in 1950, but rose to \$787.5 million for the first nine months of 1951 and are estimated at \$1,000 million for the complete year.

Europe

In Europe in 1951 the combined chemical exports of the U.K., the Federal Republic of Germany and France exceeded exports from the U.S. It is expected that, if present trends continue, Western Europe will regain the position in external world trade in chemical products which it held before the second world war.

In Europe, excluding the Soviet Union, general industrial production in 1949 exceeded the level of just before the war by 10%. It rose by another 14% in 1950. For the chemical industries the production index in 1950 (taking that for 1938 as 100) was 152, while the figure for all industrial production was 128 in the following countries, representing about 85% of total European production: Austria, Belgium,

Czechoslovakia, Denmark, Finland, France, Federal Republic of Germany, Greece, Hungary, Ireland, Italy, Netherlands, Norway, Poland, Sweden and the U.K. Progress was not, of course, uniform in every country, but generally the chemical industries expanded faster than others.

In Germany, the chemical industries have regained their pre-war place. Taking 1936 as the last year of normal peace-time production, the index rose from 91.5 in 1949 to 146 in April 1951. (There was also a marked increase in Eastern Germany.) Chemical production is fourth among industries with regard to numbers employed and second in regard to value of exports. The value of exports rose from DM 313 million (\$85 million) in 1949 to DM 2,100 million in 1951. Before the war, chemical products represented approximately 15% of German exports. This proportion dropped to 6.9% in 1948, but rose to 14.5% by 1951. A quickened rate of increase is expected to follow the ending of restrictions placed on chemical production by the Allies.

In Poland also there has been striking expansion of the chemical industries, and it seems likely that the Government will succeed in making them of first importance after coal mining.

Taking the 1938 production figures as 100 (except in the case of Austria, Czechoslovakia and Poland, when those for 1937 are used, and Belgium for which the average 1936-38 is taken), the 1950 figures of chemical production in European countries were: Austria, 206; Belgium, 152; Czechoslovakia, 140; Denmark, 139; Finland, 234; France, 118; Greece, 94; Ireland, 142; Italy, 121; Netherlands, 208; Norway, 174; Poland, 465; Sweden, 220; Switzerland (approximate), 169; U.K., 218. Average for these countries: 152.

In 1950, 25.2% of total European chemical production was British. The German Federal Republic was the next biggest European producer, contributing 18.7%.

Russia and Japan

In the Soviet Union, increased chemical production is largely concentrated on key products such as sulphuric acid, soda, nitrogen and chemical fertilisers. Total Russian industrial production increased in 1950 by 23% over 1949. Under the five-year plan, industrial production in 1950 was to exceed that of 1940 by 48%; the actual figure was 73%. For the chemical industries the plan demanded an increase

to 150% of pre-war production. The actual increase was 80%.

Japan, one of the world's five biggest chemical producers before the war, is well on the way to recovering its former place. Industrial production (1932-36 = 100) rose from 58.1 in 1948 to 96.8 in 1950. The chemical production index, now higher than that for textile and machinery production and only surpassed by the metals index, rose, after being just over 25% of its former level, from 56 in 1948 to 122.4 in 1950, well above the pre-war level. Production of basic chemical products reached the highest level among manufacturing industries.

Development programmes

The chemical industries in all countries have adopted expansion or modernisation programmes and some examples of investment are given.

The fullest possible development of chemical industries in any country is desirable. It contributes towards a flourishing export trade and lessens dependence on imports. Such development, however, requires heavy capital investment. Chemical plant deteriorates quickly because it is generally working non-stop at high temperatures and under conditions which cause corrosion. Its maintenance is costly. Also, it is often rendered obsolete, even before it is worn out, by technical advances. The amount of investment varies from country to country. It is very high in the U.S. and comparatively high in Western Europe where most of the new investment has been financed by the industries' own savings.

In under-developed countries, a considerable effort is being made to expand general industrialisation and to produce adequate quantities of fertilisers for agriculture.

In the U.S., where the chemical industry's net sales in 1950 were over \$13,000 million and net revenue \$1,364 million, investment was as follows: new plant and equipment, \$602.998 million (i.e., new structures and additions to plants, \$149.183 million and new machinery and equipment, \$453.815 million). This refers to establishments actually operating. It is estimated that total investment for new chemical plant in 1952 will reach \$1,464 million. Mention is made of the accelerated amortisation and certificate of necessity plans, put into operation by the Government after the outbreak of the Korean war.

An increase of a third in physical capacity is expected during the next two or three years. Expansion is greatest in the petrochemical branch, in which investment rose from \$350 million in 1940 to \$2,000 million at the present time. In 1951, almost 25% of all chemical products were of petrochemical origin.

Private investment in **Canada** is expected to increase by 11% in 1951 over that of 1950, or from \$2,800 million to \$3,100 million. The proposed increase in investment in the chemical industries far exceeds the average and rose from \$55.6 million in 1950 to an estimated \$75.3 million in 1951. The erection of factories for chemical products from petroleum is the most important part of the development programme.

Much smaller amounts are being invested in the chemical industries in Europe, exceptions being the U.K., France and Poland.

Investment in the chemical industries in the **U.K.** in 1949 was 7% of all industrial investment, and a long-term programme of expansion costing £191.3 million has been embarked on. A major part of the programme is concerned with heavy inorganic and organic chemicals and with petrochemicals. In all there are 927 schemes, which should result in an increased capacity of 14,231,000 tons and require 25,180 additional workers. The programme was submitted to the Board of Trade by the Association of British Chemical Manufacturers in 1949 and has been somewhat modified by changing conditions since that time.*

The **French** chemical industries received particular attention in the post-war reconstruction programme. A total investment of 48,550 thousand million French francs was planned for the total basic chemical industries, with 22.8 thousand million francs for the nitrogen and 36.2 thousand million francs for the potash fertiliser industries. The original plan has, of course, been modified, work in connection with new plant in the calcium carbide, methanol, phenol, petrochemical and dyestuffs industries being slowed up, while re-equipment and modernisation proceeds in the fertiliser industries. Most of the investment in the basic chemical industry was financed out of the undertaking's own reserves and credit, only about 18% of the total coming from the modernisation fund. In the nitrogen industry, however, investment was almost wholly financed by loans from the fund. The petrochemical branch is receiving special attention.

The **Norwegian** chemical industries have planned, and mostly carried out, a considerable investment programme since the war. Further expansion of production is under way and products not formerly made in the country are being produced.

Achievements and schemes include an increase in the output of urea from the present level of 12,000 tons p.a.; expanded production of polyvinyl chloride to 2,000 tons p.a.; output of nitrogenous products to be increased by nearly 40,000 tons; expanded production of sulphuric acid; of phosphate fertilisers from nitric acid; and production of 33,000 tons p.a. of calcium chloride.

Swedish investment in the chemical industries has risen from 60.7 million crowns in 1950 to 81.3 million crowns in 1951 and a total of 133.6 million crowns is proposed for 1952, subject to the issue of 74.1 million crowns' worth of construction licences. Plans are more extensive than those for any other industry.

In **Austria**, it is hoped that an investment programme for the chemical industries for 1950-52 will increase national production so as to raise the revenue of the country by 10% before the European Recovery Plan ends. Of a total of 8,000 million schillings for all industries, 490 millions were for the chemical industries. This amount is only exceeded by those earmarked for textile and cellulose and paper manufacturing. Investment is designed to increase capacities in nitrogen fertilisers, sulphuric acid, phosphates, soda and pigments. New projects include a petrochemicals factory and an electrochemical industry. A much higher proportion of investment will be privately financed in the chemical than in other industries.

Mention is made of the considerable assistance given to the chemical industries by the Economic Co-operation Administration, notably in the U.K., France, Italy and the Federal Republic of Germany.

In Eastern Europe, chemical industry expansion is greatest in **Poland** where, as has been noted, it is being raised to second place in the country's economy. The chemical industries are being allotted 13% of credits for industrial investment, amounts varying from year to year. First among new industries are synthetic motor fuel, synthetic rubber and phenols. Production in the chemical industries generally is to be raised 3½ times, in insecticides eight times and in pharmaceutical products seven times. The investment programme generally calls for 25 new chemical undertakings.

Total production in the **Roumanian** chemical industry is to reach 264% of its 1950 level in 1955, though the extension of existing undertakings and the construction of new factories for soda, sulphuric acid, fertilisers, medicines and the utilisation of by-products from a new factory producing 600,000 tons of coke p.a. for metallurgical purposes. Investments for the five-year period amount to 31,500 million lei at 1950 prices, out of a total industrial investment of 1,330,000 million.

Hungarian plans were enlarged in the course of execution, so that the chemical industries will increase production by

273% instead of 138%, with an investment of 4,080 million forints instead of 1,934 million. Total industrial investment was raised from 50,900 million forints to 85,000 million.

It is noted that in under-developed countries chemical development is bound up with agriculture. A low standard of living means that food production must be raised, thus making fertiliser production of first importance. This is the case in **India** and reference is made to the well-known Sindri factory (see *CHEMICAL & PROCESS ENGINEERING*, May 1952, 247-253). Indian delegates have expressed the opinion that the Indian chemical industry's potential is unlimited in terms of population, resources and needs.

In **Pakistan** an attempt is being made to popularise the use of ammonium sulphate. Consumption should reach nearly 80,000 tons p.a. during the next 5 to 10 years. In Ceylon, also, production of chemical fertilisers will begin before the end of 1952. Proposed output should meet requirements, estimated at 80,000 tons p.a. of ammonium sulphate and nearly 40,000 tons p.a. of phosphate fertilisers.

It must not be thought that, because of the need for fertilisers, Asian countries are neglecting other chemical projects. In fact, very extensive plans for expansion are under way.

In **Latin America**, not only is the output of fertilisers being expanded—sometimes with State credits or loans from the New York Export-Import Bank, as in the case of Mexico—but a change in population structure, resulting in an increase in the number of town dwellers, has made increased industrialisation essential and several expansion programmes are under way.

Some countries in Latin America have not yet passed the first stage of development of chemical industries, the production of chemical products from semi-finished or finished imports. Others have reached the second stage of manufacturing raw materials for industries producing consumer goods. Others, such as **Argentina**, **Brazil** and **Chile**, are at the third stage of producing basic materials for other industries. The report gives figures only for Chile, where chemical investment rose from under 250 million pesos in 1940 to 1,175 million in 1948.

The foregoing examples, although giving only a partial picture of world chemical investment, strikingly illustrate the dynamic nature of chemical industry development all over the world.

This section of the report ends with a reference to the Expanded Technical Assistance Programme of the United Nations and its agencies, which could be of great importance in helping to expand production and standards of living.

Raw materials

All the projects discussed depend absolutely upon raw material supplies.

*The progress of this programme up to July 1952 is described in *CHEMICAL & PROCESS ENGINEERING*, December 1952, 656.

The question of raw materials affects the chemical industries in different ways, so that in different areas projects may be diametrically opposed, according to local resources. For example, gas from oil cracking is used in the U.S. for the manufacture of synthetic rubber, while hydrogenation of natural rubber is used for producing synthetic petrol in Japan.

The present shortage, largely produced by increased demand after the outbreak of the Korean war, is aggravated by a European deficiency, since industrial production increased in Europe much more than the production of raw materials. Materials in short supply include caustic soda, carbonate of soda, calcium carbide, and especially chlorine and hydrochloric acid, benzene and industrial benzole. Much more serious is the shortage of coal and sulphur.

After referring to measures taken to ration scarce materials and to direct production towards the satisfaction of essential needs, and noting that the marked development of petrochemical industries should relieve many shortages, the report analyses the sulphur situation in detail. Much of the information given has been published already in *CHEMICAL & PROCESS ENGINEERING*, but a few basic figures help to give an overall picture of the situation. In 1950, the last year for which exact statistics are available, the quantity of sulphuric acid produced by the main producing countries was as follows (expressed in thousands of tons): Canada, 754 (100% acid); France, 1,215; Federal Republic of Germany, 1,180; Italy, 1,826 (50% Bé); Japan, 3,248 (50% Bé); U.K., 1,803 (100% acid); U.S., 12,859 (short tons, 100% acid). Total production of sulphur (thousands of tons) was 250 in Western Europe, compared with 5,275 in the U.S. Production of native and 'recuperated' sulphur by countries represented on the sulphur committee of the International Materials Conference (Australia, Belgium, Brazil, Canada, France, Italy, Mexico, New Zealand, Switzerland, South Africa, the U.K., the U.S.A., the Federal Republic of Germany, and India) was 5,914,400 long tons in 1950 when consumption was 6,329,000. For 1952, the figures are estimated at 6,255,600 and 7,596,300 respectively. Production and consumption by these countries of sulphur and raw materials in all forms were 11,242,900 long tons and 11,527,800 long tons in 1950 and estimated at 12,367,500 and 14,119,500 long tons in 1952. To meet the present scarcity of sulphur, due principally to the expansion of economic activity and the exhaustion of deposits, the following recommendations were made: in the manufacture of sulphuric acid, greater use should be made of pyrites, of the thermal treatment of foundry waste, of industrial gases and of raw materials like anhydrite and gypsum; native sulphur should be employed for essential uses when it could not be replaced by other substances; more economic utilisation of sulphur should be insisted

upon; the exploitation of native sulphur and pyrites should be begun as soon as possible in all countries having unexploited sources; countries able to furnish technical assistance to those needing it should do so.

Employment trends

With two exceptions, countries for which figures are available for at least two years show an increase in manpower in the chemical industries. For example, between 1949 and 1951 the number of chemical workers in the Federal Republic of Germany rose from 262,973 to 306,993, in Canada from 43,647 to 50,143, in the U.S.A. from 642,000 to 742,000, in Norway from 11,179 to 15,403 and in the U.K. from 432,800 to 488,300. The chemical industries are finding it hard to obtain all the staff they need, particularly in the U.S. and also in the U.K., where there is a definite shortage of both chemists and skilled workers. There is still a certain amount of unemployment in the chemical industries in certain countries, but the figures are small compared to those for industry as a whole. To take only two examples of those given in the report, in Italy in the year ending May 1951, out of 1,920,474 applications for work at unemployment offices, 14,294 concerned skilled chemical workers, and in the German Federal Republic, out of a general total of 1,292,058 unemployed, there were 11,588 skilled chemical workers.

Salaried workers

A feature of the chemical industry everywhere is the high proportion of salaried employees to wage-earners. For example, in the Federal Republic of Germany in 1950 the proportion of salaried employees was 15.6% for industry as a whole and 25.2% in the chemical industries. In Chile in 1951, of 9,510 persons employed in 279 chemical undertakings, 2,816 were salaried employees and 6,694 were wage-earners. In the U.S. in that year, of 729,000 chemical industry employees, 528,000 were workers actually engaged on production. In the U.K., statistics published by I.C.I. for their alkali branch alone show that the proportion of salaried employees has risen from 1 in 17 in 1907 to 1 in 4 at present.

Women employees

Information regarding the employment of women is difficult to analyse, because of the varying ways in which statistics are compiled in different countries, but the trend during the last three years has been for more women to be employed in chemical industries. The percentage, compared with the percentage of men employed, showed slight increases in some cases (Belgium, Norway and Federal German Republic) and slight decreases in others (U.K., Canada, Sweden and the Netherlands). The percentage of women employed is highest in Brazil, where it is 40.1%.

Payment by results

A long chapter is devoted to remuneration, particularly to payment by results. This is not yet widespread in the chemical industries, but there is evidence that it is increasing, and that its introduction has been successful and acceptable to workers. In the U.S. payment by results has been adopted to a much less extent in the chemical than in the clothing and textile industries, and extended to only 7% of personnel. In the U.K., in 1949, 22% of establishments in the chemical and allied trades employed the system, but only 14% of workers were paid under it. In the Scandinavian countries and the Netherlands, the piecework system is much more widely applied, notably in Norway, where in 1948 the percentage of piecework was 63.2% for male and 59.6% for female workers.

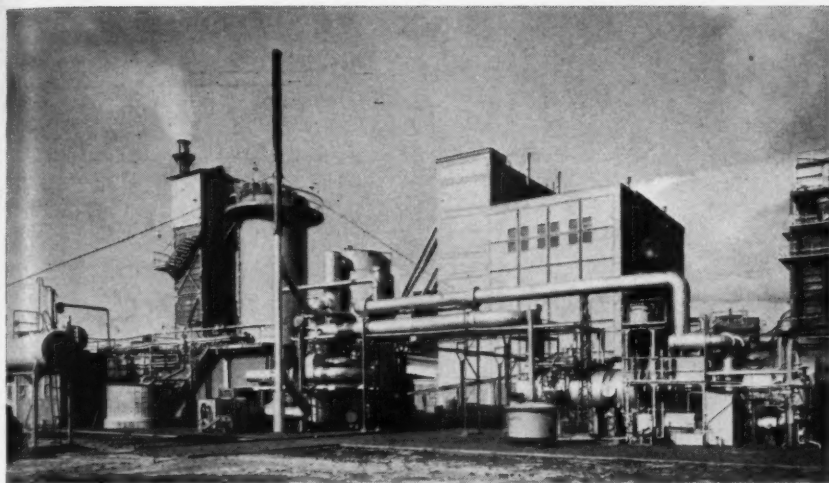
Objects of the system

The number of workers paid by results shows a tendency everywhere to increase with the size of the undertaking. The objections to payment by results are, firstly, the diversity of production in the chemical industries—certain products requiring little manpower may have a higher commercial value than those requiring more effort; and, secondly, the fact that the production worker's output is decided in advance in most cases by the nature of the work, the duration of the process being precisely fixed, so that an output can only be altered to the extent that careful maintenance and anticipation of faults can cut production losses. Finally, it is difficult to devise payment by results for the large number of maintenance workers, machine attendants and workers whose duties are almost entirely supervisory.

Bonus payments

The report describes how these difficulties have been overcome by the devising of various sorts of bonus. Some, for maintenance and supervisory workers, are based on the competence and intelligence brought to the work. This is reflected in overall increased output and instrumental recordings showing that specified conditions have been maintained and that consumption of fuel and raw materials has been kept down. Many details must be considered when working out these bonuses, in order to calculate the exact nature of the work and the qualities required. A graph is used to show the very substantial increases of production which have been obtained in one case when payment by results was introduced.

It is not part of the present survey to advocate the adoption of payment by results, but the opinion is expressed that, in countries like the U.K. where full employment has largely absorbed reserves of manpower, payment by results may be the best means of obtaining increased production and increased productivity.



The new sulphuric acid plant at Pernis. The raw material used is hydrogen sulphide.

Modernisation of Dutch Fertiliser Factories

As part of a 24½-million-guilder post-war modernisation and expansion programme the Dutch fertiliser manufacturers, Albatros Superfosfaatfabrieken N.V., of Utrecht, have installed a number of new plants.

Consideration has been given chiefly to the production of high-grade granular fertilisers; the company makes a wide range of products including superphosphate, triple superphosphate, ammonium phosphate, concentrated compounds, trisodium phosphate, sodium silico fluoride and technical phosphoric acid.

The output of phosphoric acid has been considerably increased by the addition of a new plant with an adjacent evaporation unit. In order to ensure a larger supply of sulphuric acid, a small plant, burning hydrogen sulphide, a waste product obtained from the adjacent oil refineries, was built at Pernis (Rotterdam). This plant makes full use of the heat generated by converting it into steam.

Granulation plants, partly for the granulation of powder products processed by existing plants, and partly combining processing and granulation, have been erected both at Amsterdam and Pernis. The installations can be used for superphosphate and triple superphosphate as well as for compound fertilisers.

These developments also necessitated the creation of a new central laboratory for all the factories, which has pilot-plant facilities.

In addition to the new chemical plants the firm has installed extensive mechanical handling equipment in its factories and sheds and at the wharves. This year the company celebrates its 75th anniversary.

Safer acid handling system

A special acid-handling system that stores, distributes and disposes of acidic waste solutions is increasing the factor of safety, reducing processing hazards and operating costs and contributing to more effective production, according to the Norris Thermador Corp., Los Angeles, California. As described in *Plant Engineering*, the system, which has a total holding capacity of 12,000 gal. of 98% sulphuric acid concentrate, includes a pressure-balancing standpipe arrangement that provides a pressure control consistent with operating requirements; an isolated distribution line that speeds and simplifies maintenance; a self-regulating device that stops operations if equipment fails; and facilities for waste disposal that give added production efficiency. A metering feed tank through which the acid is fed into a process receiving tank and the use of gasket connections on all piping, reduce

leakage and decrease further the danger of injury to employees or equipment.

In transferring the acid from tank cars to the 10,000- and 2,000-gal. storage tanks, the tank car is pressurised to 25 p.s.i. Prior to entering the tank car, the air is shunted to a 25-ft. standpipe to prevent any acid backflow into the system. Another pressure-balancing standpipe 50-ft. high controls the acid flow into the storage tank. Moisture is held in a water trap.

Acid is fed from the pressure tanks into processing receiving tanks through a lead-line meter box with a visual gauge to prevent spluttering air charged with acid particles from injuring employees.

A 500-gal. pressure tank—the only area outside the circulation pipes where full-time pressure is maintained—constitutes the vital unit in the acid distribution network. Pressurised to 25 p.s.i., air enters this tank through a third standpipe and leaves through a 3-in. pipe. By locating

the main acid distribution pipe in closer relationship to the bottom of the working tank than the vent pipe, the danger of compressed air containing globules of acid spurting out into the open is eliminated. When the working acid level falls below the open end of the vent pipe the tank is automatically de-pressurised via an outlet on the 2,000-gal. storage tank, preventing the destructive acid spurts.

Waste disposal is accomplished through the use of a portable 1,000-gal. disposal tank that can be trucked to commercial disposal accommodations, and a 2,000-gal. sump into which wash-out water with a 2 to 5% acid content is drained through lead-lined pipes.

Increasing the capacity of fractionating towers

The problem of overloaded atmospheric towers in crude distillation units and the corresponding need for increased fractionating capacity can now be solved by petroleum processors by the addition of cylindrical sections to an existing fractionating tower, according to the experience of the Phillips Petroleum Co., Bartlesville, Oklahoma. A 16-ft. tray extension added to the fractionating tower at this company's Sweeny, Texas, refinery has permitted a reliable increase in production output.

Efforts to increase production at this plant using existing facilities proved unsuccessful. A solution appeared to be to enlarge the capacity of the crude distillation unit, and this involved a corresponding increase in the fractionating ability of the related tower equipment.

As reported in the *Oil and Gas Journal*, it was decided eventually to increase the capacity of the crude unit from 30,000 to 40,000 barrels/day, by rearranging the heat-exchanger system and that of the fractionating tower by an appropriate height increase. To accomplish this, it was necessary to cut off the top of the atmospheric tower, adding a cylindrical portion containing eight numbered trays and a new hemispherical dome section at the top of the tray extension.

The original fractionating tower portion consisted of a reduced steam-stripping section with four trays and a main tower area with twelve trays. By adding the 16-ft. extension with eight trays, the total tower tray composition has been increased from 12 to 20. The charge enters the fractionating tower as a steady bottom stream from the flash tower of the crude distillation unit. During installation of the 16-ft. extension, the top portion of the tower was hoisted in a cocked position. On nearing the tower top, the dome was righted for easier handling.

The additional height of the tower has to be limited to 16 ft. because the maximum lift of the only crane available for use in installing the extension could accommodate no more than a 16-ft. increase plus the new hemispherical top section.

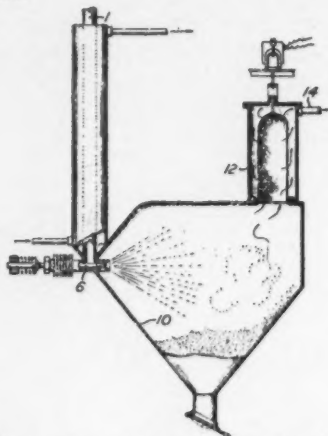
Chemical Engineering Invention

MONTHLY SUMMARY OF PATENT CLAIMS

Melamine manufacture

A substance from which melamine is obtainable is heated in the presence of ammonia, and in the presence or absence of other gases such as nitrogen or carbon dioxide.

This heating is performed under such conditions of temperature and raised pressure that the melamine is vaporised without decomposition and is withdrawn from the reaction vessel while still in the vapour phase.



The preferred starting material is dicyandiamide, but other materials which may be used are urea, cyanamide, guanyl-urea, cyanourea, biuret, guanidine, cyanuric acid, ammelide, ammeline, melam, melem and mellon. The reaction temperature should be at least 350°C. and the partial pressure of the ammonia at least 750 p.s.i., but the reaction may be effected at a temperature rising to above 600°C. and at a total pressure up to 5,000 p.s.i. Suitable combinations of conditions within these limits are specified.

The starting material, which may be a solution or suspension of dicyandiamide in liquid ammonia, is fed under pressure to a heated tube 1, from which the reaction products are withdrawn as vapour through a pressure-operated valve 6 into a collector 10 at atmospheric pressure, wherein melamine condenses as a powder without passing through an intermediate liquid phase. The uncondensed gases pass through a filter 12 to the outlet 14. The tube 1 need not be vertical, but may be horizontal or inclined or may be a U-tube. Specification 502,148 is referred to.—641,643, American Cyanamid Co.

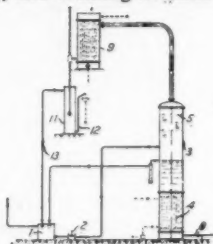
Catalysts for hydrocarbon synthesis

An iron, cobalt or nickel catalyst for use in the synthesis of hydrocarbons or oxygenous derivatives thereof and which is free from alkali silicates is prepared by precipitating the metal partly in the form

of a silicate and partly in the form of a readily reducible basic compound and then reducing with hydrogen. The catalyst may be supported on a material, e.g. sintered kieselguhr, alumina, carborundum, magnesium silicate, magnesium carbonate, barium sulphate and metallic powder or grit, which does not appreciably contribute to the formation of silicates with the catalytically active metal. The catalyst is suitable for use with the fluidised technique or may be employed in the form of pellets. In an example soda and sodium metasilicate are added to a solution of the nitrates of cobalt, magnesium and thorium, and alumina (support) is added and the precipitate separated, washed, pelleted and reduced with hydrogen.—640,311, N/V de Bataafsche Petroleum Maatschappij.

Dehydrating tar by azeotropic distillation

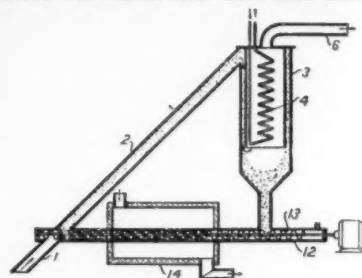
Crude coal tar or similar products are dehydrated by azeotropic distillation using an added light hydrocarbon oil, such as benzole, as water-entrainer. After condensation of the vapours and separation of water from the condensate, the light oil is recycled to the still in admixture with the crude tar. Dehydration down to a water content of only 0.1% is thereby carried out at a low temperature, i.e. close to 100°C., and foaming is eliminated.



The tar may be dehydrated in column 3 which is fitted with a steam-heater 4 and perforated splash-plates 5. The top of the column is connected to a condenser 9 and decanter 11. Tank 1, to which the crude tar is supplied, is connected to the side of the column by two routes; one contains a pump 2 for supplying feed to the column, while the other is for the return of over-flow from the constant liquid-level in the column. About 100 litres of light oil are added for every cubic metre of tar in the column, and the temperature of the liquid is raised to 100 to 110°C. to distil off the azeotropic mixture. The vapours are condensed and the condensate is decanted, water being discharged through pipe 12, while the light oil is passed to tank 1 through pipe 13. Dehydrated tar is withdrawn from the base of column 3 through pipe 8.—640,178, Soc. pour l'Exploitation des Procédés Ab-Der-Halden.

Catalytic apparatus for controlling exothermic reactions

In vapour or liquid phase exothermic reactions, e.g. polymerisation and hydrogenation of hydrocarbons, wherein the reactants are passed along with a finely divided catalyst through a reaction zone, the catalyst enters the reaction zone at a temperature substantially below the reaction temperature. It thus serves to absorb the exothermic heat and control



the reaction. The preheated reactants enter the reaction zone 2 from line 1 and pick up the powdered catalyst from line 12 containing screw-conveyor 13. The mixture of catalyst and reaction products leaving the reaction zone is separated in, for example, a cyclone separator 3 and the separated catalyst is returned to the reaction zone through line 12 wherein it is cooled to the desired temperature by cooler 14. The reaction products are quenched in separator 3 by a cooling coil 4 and are withdrawn through line 6.—640,466, Universal Oil Products Co.

Solvent standards. The British Standards Institution has issued two further standards in the series for solvents and allied products: Ethyl methyl ketone (B.S. 1940: 1953) and isobutyl methyl ketone (B.S. 1941: 1953). British standards for these materials were not included in the original series of standards for solvents, although a British Standard Aircraft Material Specification 3.D.1, 'Methyl ethyl ketone,' was published in 1929. The standard of production of this material has now improved and the demand for general purposes has increased. The new standard, 'Ethyl methyl ketone (Methyl ethyl ketone),' therefore supersedes specification 3.D.1, which has been withdrawn.

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World News

GREAT BRITAIN

Pilot-plant gas scrubber

The Power-Gas Corporation Ltd. who are the licencees for the Pease Anthony scrubbers, now have a pilot-plant unit available for experimental purposes on a variety of applications. The unit is mobile and can handle 500 cu.ft./min. of gas and is capable of dealing with micron and sub-micron dusts and fumes.

Mond Nickel fellowships

The Mond Nickel Fellowships Committee now invites applications for Fellowships of an approximate value of £900 to £1,200 for 1953. Fellowships will be awarded to selected candidates of British nationality with degree or equivalent qualifications to enable them to obtain wider experience and additional training in industrial establishments, at home or abroad, to make them more suitable for future employment in senior technical and administrative positions in British metallurgical industries. Each Fellowship will cover one full working year. Applicants will be required to state details of the programme they wish to carry out. Particulars and forms of application are available from the Secretary, Mond Nickel Fellowships Committee, 4 Grosvenor Gardens, London, S.W.1. Completed application forms are required by June 1, 1953.

I.C.I. director retires

Sir Arthur Smout retired from the board of Imperial Chemical Industries Ltd. on February 28. He was appointed to the board in 1944 and in the same year became Metals Group Director. In July 1951 he also took over responsibility for the Nobel Division.

Sir Arthur served for 48 years with the company and its predecessors, having joined Elliotts Metal Co. Ltd. in 1905. From 1934 until 1942 he was chairman of the Delegate Board of I.C.I. (Metals) Ltd. From 1942 to 1945 he was Director-General of Ammunition Production at the Ministry of Supply, being knighted for his services in 1946.

Balfour appointment

Mr. Robin Thomson, C.A., of Dundee, has been appointed to the board of Henry Balfour & Co. Ltd. in place of Mr. William Watson, who recently resigned to take up his post as Treasurer of the Bank of Scotland.

Detergents and sewage processing

The problem of detergents in sewage, bubble trouble, as he called it, was discussed by Mr. G. N. Swayne in his presidential address to the Society of Engineers' entitled 'Public health engineering.' He said that some detergents seem to be able to pass right through the various sewage processes and discharge

into the river without losing their foaming properties. As so much of our household water was drawn from rivers it was not unlikely that ready-made suds might emerge from household taps. The Metropolitan Water Board was seriously concerned and had asked for a Government investigation. When it was realised that the River Lea provided about one-sixth of London's supply and that foaming had occurred in the river about 12 miles above the point of intake, the seriousness of the problem could be appreciated. Much more experimental work had to be done and Mr. Swayne hoped that makers of detergents would collaborate fully.

Discussing river pollution and the powers given to the new River Boards to demand higher standards of purity, Mr. Swayne said that, while it was practicable to design disposal works to produce these high standards, they were very expensive to build and to maintain. In any case, although River Boards could obtain a court order for the building of new effluent treatment plants, local authorities were prevented from building by Government restrictions on capital expenditure.

Petrochemicals' new laboratories

Petrochemicals Ltd., who have concentrated for some time on establishing their own chemical research organisation, took a further step towards this aim recently when new laboratories at their Partington, Cheshire, works were opened by Sir Robert Robinson, O.M., F.R.S., a director of the company.

After touring the well-equipped new quarters, Sir Robert, in a brief address to the senior technical staff, stressed the need for Petrochemicals to do its own research. 'No chemical company worthy of the name,' he said, 'can hope to succeed unless it has established an active research department in constant touch with every field of industrial endeavour and able to open up new lines of development.'

The research laboratories, together with laboratories engaged on product development, technical service and pilot-plant work, form a division embracing all aspects of scientific progress in the petroleum-chemicals field allied to industrial development.

Propylene glycol made

Propylene glycol is now being made in commercial quantities in Great Britain. Until now, the propylene glycol available in the U.K. has been imported from America and Canada. Owing to the scarcity of dollars, imports have been restricted.

It is stated by the manufacturers, Petrochemicals Ltd., that technical, food-stuffs and B.P.C. grades of propylene glycol can now be supplied in quantity.

Chemical engineers' annual dinner

The 31st annual corporate meeting of the Institution of Chemical Engineers is to be held at the May Fair Hotel, Berkeley Street, London, W.1, on April 23. After the business session at 11 a.m., for corporate members only, the presidential address will be given at noon by Mr. Stanley Robson on 'Changes in roasting practice and furnace design.' At 3 p.m. a film, 'The Stanlow Story,' will be shown at the British Council Film Theatre, Hanover Street, W.1. Applications for tickets for this should be made to the Secretary, Institution of Chemical Engineers. This will be followed at 7 p.m. by the annual dinner.

The annual dinner of the Chemical Engineering Group of the Society of Chemical Industry will be held at the Hotel Rubens, Buckingham Palace Road, London, S.W.1, at 7 p.m. on April 10. The principal guest will be the President of the Society, Mr. Francis J. Curtis.

TURKEY

Tenders required for acid and superphosphate plants

The British Embassy at Ankara reports that the Etibank of Turkey is proposing to erect a sulphuric acid plant at Murgul and a superphosphate plant at Hopa. The sulphuric acid plant at Murgul will treat the SO₂-containing gases of Etibank's copper smelter and the resultant acid will be transported to the superphosphate plant at Hopa.

The sulphuric acid plant at Murgul will produce 160 tons of 66° Bé acid in 24 hr., and the superphosphate plant at Hopa will produce 140 tons of superphosphate fertiliser with 48% P₂O₅ in two 8-hr. shifts a day.

United Kingdom firms specialising in the construction of such plants are invited to submit tenders to the Etibank for the supply of machinery, equipment and material necessary to the erection of the undermentioned plants as well as auxiliary equipment and accessories; for the preparation of the necessary designs and plans; for the supply of the necessary specialised technicians to erect the plants and for the supervision of the erection and initial operation.

The installations to be erected and/or delivered and the work to be done are composed of six individual units: roasting plant; sulphuric acid plant; treatment of reverberatory furnace gases; superphosphate plant; acid storage tanks; and tanker trucks.

The bidding file and related details can be inspected at Room 7170 at the Board of Trade, Horseguards Avenue, S.W.1. Manufacturers considering tendering should refer to Special Register Circular GEN 683 dated June 11, 1952, and headed 'Notification of Calls for Tender Issued Abroad.'

The closing date for tenders is June 15, 1953, at the offices of the Etibank in Ankara.

Industrial projects planned

A project has been announced for the erection of a paper mill on the River Halkapinar at Izmir. It would use cheap, on-the-spot raw material, such as raw cotton waste and tobacco stalks.

The Ankara Municipality has formed a T£9 million company, to modernise and enlarge the existing Ankara cement factory, built in 1926. The aim is to increase its present output from 15,000 to 60,90,000 tons p.a.

The Batman oil refinery, construction of which was announced in our March issue (p. 89), should be completed in two years and have a capacity of approximately 330,000 tons p.a. Present output of crude oil from the Romand and Garzan wells is only roughly 20,000 tons p.a.

The Turkish Sugar Corporation reported 1952 production as 163,000 tons, which was 18,000 tons below that of 1951. In view of the steady rise in local consumption, the establishment of further refineries is being discussed. The necessary capital of T£8 million for one at Kutahya has already been raised.

A new corporation, with T£500,000 capital, of which T£350,000 has been subscribed by the Industrial Development Bank, who are also lending the corporation a further T£1 million is to take over the existing obsolete fish canning plant on Marmara Island. The new plant is to have a daily capacity of 5 tons each of sardines, mackerel and tunny. It is intended to can vegetables during the off season for fish.

The necessary capital for the T£4 million local company, which must participate in the Seyhan Dam hydro-electric project backed by an I.B.R.D. (International Bank for Reconstruction and Development) loan of \$25.2 million has now been raised. An American firm has been appointed as consultants.

SPAIN

More metals, chemicals and oil

The Spanish Minister of Industry has spoken of the increased production in certain industries and said it was governmental policy to foster higher output of raw materials and basic products.

He said that steel production in 1952, which was 905,000 tons, did not entirely reflect the increase in pig iron output of 750,000 tons, because of a reduction of 20,000 tons in imports of scrap. The aim for pig iron output was 1,050,000 metric tons in 1953; 1,180,000 in 1954; 1,300,000 in 1955 and 1,400,000 in 1956. The new plant at Aviles, on Spain's north coast (for which contracts have just been placed), will have an eventual capacity of 700,000 tons, of which 350,000 will be available by late 1956 or early 1957.

The Escombreras petroleum refinery at Cartagena had reached full production capacity of 1,500,000 tons p.a., the Minister said. Production capacity for nitrogen fertilisers in Spain would reach 200,000 tons p.a. in 1953, against estimated consumption of 550,000 tons.

Lack of fuel was slowing down expansion in cement, output of which was scheduled to reach 2,750,000 tons this year, 3,500,000 in 1954 and 4 million in 1955. Domestic production of copper was insufficient, but increased production of pyrites should give Spain an extra 30,000 tons of copper by about 1957. The Hinojedo plant should start production this year and would initially make available 7,000 tons of sulphur p.a. Steps were being taken to step up aluminium production at the Empresa Nacional de Aluminio plant at Valladolid to 7,000 and later to 10,000 tons p.a.

The Minister stated that, in 1952, prices had tended to remain stable. Where the cost of raw materials had been reduced, some goods had actually decreased in price, for example, paper, rubber tyres, ceramics, building materials and textiles. Others had gone up in price, e.g. sodium nitrate, superphosphates and sugar.

CEYLON

Financing of state industries

The Ministry of Industries has submitted a statement of amounts required for vital expenditure for the various industrial projects which are to be reviewed by the Cabinet. The following are the principal components of the full amount required (Rs. 7,500,000): paper factory, Rs.4.99 million; iron and steel factory, Rs.0.5 million; caustic soda factory, Rs.1.75 million; acetic acid factory, Rs.0.1 million; glass factory, Rs.0.2 million; iron ore dressing plant, Rs.0.4 million.

The manner in which most State-sponsored industrial and commercial ventures have been run has caused concern, not least for the Government. A commission appointed in 1951 to investigate and report on past losses has yet to lodge its findings. A Bill for the formation of industrial corporations has received the Government's tentative approval and is generally expected to be enacted in due course. Meanwhile, the first factory to be established on this basis will be a brick and tile plant to be set up 25 miles north of Colombo.

PAKISTAN

New oil well

Pakistan Petroleum Ltd. claim to have struck oil at Chaknaurang, near Chakwal, in the Punjab, with the first well they have drilled there. Following an acid treatment to open up the fissures of the productive limestone, the well yielded about 200 barrels of crude oil in 24 hr. Unfortunately this crude contains a large proportion of asphalt and, although it has not yet been possible to complete a proper analysis, it almost certainly contains only small quantities of light oils. The company point out that, in view of the fact that the extent of the oil pool has yet to be determined and the oil is of poor quality, it is too early to assess the success of this find.

AUSTRIA

Plastics industry expanding

In the current year a new plant for the manufacture of polyvinyl chloride will come into production at Hallein, near Salzburg. The plant has been partly financed with Marshall Aid and its output is expected to make the country largely independent of imports of this plastic. Annual requirements of PVC are put at 1,500 tons and demand is still rising.

The Voest iron and steel works of Linz have completed a phenol plant which is expected to meet about 35% of the country's requirements. Previously, phenol has been imported mainly from Britain, West Germany and Belgium.

It is estimated that some 8,000 tons of plastic materials were processed in Austria during 1952, of which 3,000 tons were imported. In 1951, 5,000 tons were processed.

Increase in carbide industry

Austrian carbide plants have been increased during the past few years and the country produced more than 15,000 tons of carbide in 1952. She is now able to export carbide, besides satisfying domestic demands. Monthly carbide production has risen to an average of more than 1,000 tons since June 1952, compared with a monthly average of 409 tons in 1937 and 982 tons in 1950. In September 1952, a record figure of 1,911 tons was achieved.

SOUTH AFRICA

New soap plants

Dr. C. H. Clarke, of London, technical director of the Unilever soap organisation, said in Cape Town that plant costing about £250,000 had now been installed in the organisation's Cape Town, Durban and Johannesburg factories to make soap by a new method giving continuous production. The plant at Durban and Johannesburg was already in production. The new method was highly mechanised. The main feature of the process was its continuity, from liquid soap to wrapped and packed bars, delays for cooling and other reasons being eliminated. His firm had great confidence in the Union and was continually expanding its factories there and improving its manufacturing methods.

[Editor's note.—We understand that a similar continuous soap-making plant is in operation at Bristol.]

New phosphate project

A new project to develop the phosphate deposits in the Transvaal is being sponsored by the Government. It is hoped to make South Africa independent of imports in the event of war. A new factory is planned and preliminary work on the site is in hand. Tenders for plant and buildings have been invited by the Phosphate Development Corporation. The new concern is known as Foskor and it is hoped that it will produce phosphate rock concentrate for the fertiliser industry at competitive prices.

Wood pulp from eucalyptus

The Industrial Development Corporation, Courtaulds and Snia Viscosa are jointly to establish a factory to produce wood pulp from eucalyptus saligna timber suitable for use in the viscose rayon industry. Preparatory work at Umkomaas has begun.

KENYA

Call for tenders for sewage pumping plant

The city of Nairobi has called for tenders for the supply of sewage pumping plant for the proposed Nairobi River Valley pumping station. The plant will consist of four electrically-driven pump units, one diesel oil-fuel-engine-driven pump unit and one electrically-driven disintegrator pump unit. The centrifugal pumps will be of the self-priming type. Vacuum priming equipment may be driven from the shaft of each main pump or by a separate motor and pump coupled with a vacuum vessel.

The disintegrator pump will be suitable for periodically dealing with the accumulation of screenings from 1,200,000 gal./day of sewage held on the $\frac{1}{2}$ -in. fine screen.

The feed to this pump will be by gravity, controlled by a manually-operated sluice valve and the electrical starting gear will be manually operated. The pump will be required to deal with a minimum of 8 cu.yds./day of screenings in loose condition. The screenings will contain a considerable proportion of rags and coarse vegetable matter. The minimum discharge rates of the individual pump range from 850 to 2,550 gal./min. The static head will be 32 ft.

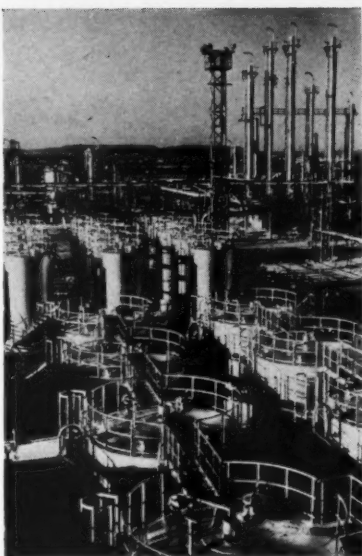
Complete details of the plant required are available at Room 7154, Board of Trade, Horseguards Avenue, S.W.1. Tenders must reach Nairobi by 11.30 a.m. on May 11. Tender documents must be obtained from the City Engineer there.

The U.K. Trade Commissioner at Nairobi has reported that the Uplands Bacon Factory have invited applications from experienced contractors willing to tender for the construction of a sewage purification works, consisting of a sewer, two pump houses, a rising main, screening chamber, grease tank, percolating filter with revolving sprinkler, 35,000-gal. sedimentation tank, sludge digestion lagoon, sludge beds and sundry pipelines. Applications have to be made in writing to Messrs. Stirling & Scott, consulting geological and civil engineers, P.O. Box 245, Nairobi. The construction of the sewage purification works is to be at the factory.

New cement factory

An £800,000 cement factory now being built at Mombasa is expected to produce 100,000 tons of cement p.a.—enough to meet Kenya's entire needs. This has been announced by Dr. F. Mandi, East African manager of the British Cement Co., which is building the plant.

It will be finished in six months and



Shell's new plant for the manufacture of solvents from petroleum at Berre, near Marseilles—the first in France. See page 94.

production is expected to begin by the end of 1953. This will enable Kenya to cut its annual cement imports from Britain by £1,050,000.

UGANDA

A cement factory has been built at Torero, eastern Uganda, at a cost of £2,451,000. Plans exist to double production of the plant as soon as possible, as the present production of 55,000 tons p.a. will be only a proportion of Uganda's requirements.

NEW ZEALAND

New tissue-paper mill

A £500,000 mill for the manufacture of tissue papers is to be built and operated at Henderson by Auckland Paper Mills Ltd. The mill is expected to save a considerable sum of foreign exchange, as practically all the tissue paper used in New Zealand during the past 25 years has been imported from Canada.

Sulphur purchases to be increased

New Zealand seeks contracts with four major U.S. suppliers for a total of 125,000 tons of sulphur this year and a similar amount in 1954. This was disclosed by the N.Z. Minister of Agriculture, following the announcement of the freeing of sulphur from international control.

He said that, although New Zealand's sulphur requirements this year were put at 96,000 tons, she would try to take advantage of the present position. He added, however, that he could not regard this 'welcome improvement' in the sulphur position as 'anything more than a temporary respite.' New Zealand must continue to push ahead with her plans for fertiliser works which did not need crude sulphur.

AUSTRALIA

Acid-from-pyrites plant

Work is to begin shortly at Port Adelaide, South Australia, on a large pyrites-burning sulphuric acid plant. It is being built by Simon Carves (Australia) Pty. Ltd., who state that it will cost around A£2 million and will have the capacity to produce 100,000 tons of acid p.a., or enough for 300,000 tons of superphosphates.

Some of the equipment will be built in Australia. The rest will come from England.

UNITED STATES

Rapid tanning process claimed

Leathers finished by a new rapid tanning method have been produced by Secotan Inc., of Somerville, Mass., who state that leather can be tanned in 4 min.

Secotan has been financed in part by the American Research & Development Corporation, whose president states that, on the basis of new knowledge of protein chemistry, new and very rapidly reacting tanning substances have been evolved. Standard chemicals are used, he adds, and they are not in the strategic category as was chromium for chrome tanning during the last war, nor are they dependent on foreign sources as are some present tanning acids.

Underground gas storage

More than two-thirds of all the fields used for storing natural gas underground in the U.S. are in the Appalachian region, according to an information circular released by the Bureau of Mines, U.S. Department of the Interior. The combined capacity of 101 fields in this region exceeds 526 billion cu. ft.

Storage of natural gas near points of consumption is necessary to smooth out seasonal variations in demand. Underground storage provides greater capacity at lower unit cost than other types, the Bureau report points out. The practice began in 1915, growing into major proportions only in the last 12 years.

The potential hazard of gas leakage from storage fields in coal mining areas is discussed in the report. Neither the gas storage companies nor the coal mine operators can afford leakage, and the report calls for complete co-operation between the two fuel industries to reduce this hazard.

The factors involved in selecting and developing storage fields are described. Many of the projects utilise old natural-gas fields that were abandoned when their naturally occurring reserves of gas became exhausted. The primary consideration of any storage field is that it must be gas-tight.

Prepared as a general information circular by two Bureau petroleum engineers, H. P. Wheeler, Jr., and W. E. Eckard, the report takes into account the co-existence of coal mining, and natural gas storage in the Appalachian region and stresses the need for close co-operation between the

two to achieve safe operation. The circular is supplemented with numerous charts and diagrams.

A free copy of Information Circular 7654, 'Underground Storage of Natural Gas in Coal-Mining Areas,' may be obtained from the Bureau of Mines, Publications Distribution Section, 4800 Forbes Street, Pittsburgh 13, Pa.

Chemical prices held down

Prices in the chemical industry declined in almost every month of the past year, according to a statement issued by the Manufacturing Chemists' Association. Many prices, such as those for antibiotics and chemical textile fibres, have declined sharply.

The wholesale price index of chemicals and allied products as compiled by the U.S. Bureau of Labour Statistics is only 3% higher than before the Korean war, as compared with the index for all other commodities which is almost 11% higher.

The chemical industry has been able to hold down price increases because of new and improved processes developed, keen competition and large investments in new and more efficient plants.

New unit for Esso refinery

Esso Standard Oil Co. has awarded the contract for a 60,000 barrel/day crude distillation unit at its Bayway (N.J.) refinery to the M. W. Kellogg Co. This addition to Esso's production facilities will provide a major increase in the crude capacity of the Bayway refinery, largest on the East Coast.

The unit, itself, will be a three-stage plant similar in design to two now under construction by Kellogg for Esso at its Baton Rouge refinery. Engineering is currently under way with actual erection scheduled to start in early summer.

The installation at Bayway refinery of what was then claimed to be the largest single fluid catalytic cracking unit in the world was described in this journal in February 1950.

MEETINGS

Institution of Chemical Engineers

April 11. 'Efficiency of the Kaskade distillation column,' by F. H. Garner, S. R. M. Ellis and A. J. Hugill, 3 p.m., North Western Branch, College of Technology, Manchester.

April 14. 'The fractionation of liquid air,' by G. C. Haselden, 5.30 p.m., Geological Society, Burlington House, London, W.1.

Chemical Society

April 9. 'Some equilibria and reactions with sulphur,' by Dr. G. Gee, 5.15 p.m., Chemistry Department, University College, Dundee.

April 24. 'Metal halide catalysts,' by Dr. F. Fairbrother, 5.15 p.m., Chemistry Department, United College, St. Andrews.

April 30. 'The scientific problems of surface catalysis,' by Prof. H. S. Taylor, 7.30 p.m., Chemical Society, Burlington House, London, W.1.

April 30. 'Some properties of high-polymer solutions,' by Prof. C. E. H. Bawn, 5.45 p.m., Department of Chemistry, University College of North Wales, Bangor.

May 5. 'Research and development on refractory materials,' by Dr. A. T. Green, 7 p.m., Chemistry Department, The University, Bristol. Joint meeting with the R.I.C., S.C.I. and the Institute of Fuel.

May 8. 'Allene chemistry,' by Prof. E. R. H. Jones, 5.30 p.m., Chemistry Building, King's College, Newcastle-upon-Tyne.

Society of Chemical Industry

May 4. 'Standardisation of shellac and lac products,' by Dr. G. W. Ferguson, 6.30 p.m., Chemical Society's Rooms, Burlington House, Piccadilly, London, W.1.

Fine Chemicals Group

April 17. Annual General Meeting followed by 'Isolation of fine chemicals from natural sources,' by Dr. Wm. Mit-

The Leonard Hill Technical Group

Articles published in some of our associate journals in the Leonard Hill Technical Group this month include:

Manufacturing Chemist—Instruments and Control Gear for Chemical Plant; Radiochemical Laboratory Equipment; Modern Veterinary Medicaments, Part 3; Chemotherapeutic Control of Piroplasmosis; Hexachlorophene and D.C.M.X. as Disinfectants for Soaps; Progress Reports of Chemotherapy, Fertilisers and Cosmetics.

Food Manufacture—Bacteriological Examination of Canned Hams, Part 2; The Vitamin Industry—Progress in 1952.

Building Digest—The Painting of Buildings, Part 2; The Psychology of Colour in Schools.

Muck Shifter—The Danube-Black Sea Canal; The Chesapeake Bay Bridge; A High-Speed Pipeline Operation at Harburg Refinery.

World Crops—Willows—A Valuable Genus; Western Canada's Irrigation Scheme; The Bangweulu Swamps; Cultivation of Rice in Egypt; Farming within the Arctic Circle.

chell, 7 p.m., Chemistry Lecture Theatre, King's College, Strand, London, W.C.2.

Royal Institute of Chemistry

April 16. 'Synthetic soil conditioners,' by Dr. W. McG. Morgan, 8 p.m., Luton Town Hall.

April 20. 'The physics and chemistry of detergent solutions,' by Dr. K. G. A. Pankhurst, 7 p.m., Medway Technical College, Gardiner Street, Gillingham.

Fertiliser Society

April 23. 'Ammoniation of superphosphate,' by J. Angus, 2.30 p.m., Royal Station Hotel, York.

Institute of Fuel

April 28. 'Refractory recuperators,' by Prof. A. L. Roberts, 5 p.m., Institution of Mechanical Engineers, Storey's Gate, London, S.W.1.

Institute of Metals

April 9. Annual General Meeting followed by 'The basic processes involved in the tempering of plain carbon and low-alloy steels,' by Dr. W. S. Owen, 6.30 p.m., Liverpool Engineering Society, The Temple, Dale Street, Liverpool.

Institute of Refrigeration

April 21. 'An analysis of the factors affecting performance of small compressors,' by W. B. Gosney, 5.30 p.m., The Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1.

CONFERENCES

April 16-18. Fiftieth Anniversary celebrations and 100th General Discussion of the Faraday Society: 'Equilibrium properties of non-electrolytes,' London.

April 26-29. American Institute of Chemical Engineers and Chemical Institute of Canada, joint meeting, Toronto, Canada.

CHEMICAL & PROCESS ENGINEERING

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